POWER RESOURCES OF THE WORLD

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POWER RESOURCES OF THE WORLD

(POTENTIAL AND DEVELOPED)

Preface by

D · N · DUNLOP O·B·E

CHAIRMAN

INTERNATIONAL EXECUTIVE COUNCIL

WORLD POWER CONFERENCE

LONDON

WORLD POWER CONFERENCE

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PREFACE

EVEN a few years ago any investigation which aimed at assessment of the power resources of the world would have been regarded as one of those pleasant exercises in prophecy and vague deduction which only a statistician in his leisure moments would attempt. Yet, the future industrial expansion of the world, if it is to be carried out on a scientific basis, or if it is to be influenced by a broad and genuinely progressive policy, must depend on a fairly accurate conception of the resources which are available in each country and the possibilities which exist for making economic use of them.

From time to time special conferences have met which dealt with particular aspects of the subject, but hitherto no attempt has been made to assess the work of these different conferences and establish some common basis of evaluation, which might serve as a beginning of a much wider movement towards the study and exact registration of all the power resources of the world. In recent years, two important international conferences have dealt with the subject on the broadest lines, namely, the First World Power Conference of 1924, held in London, and the International Economic Conference of 1927, whose deliberations were carried out at Geneva under the auspices of the League of Nations.

For each of these Conferences, a number of important studies bearing on the leading industrial countries of the world was prepared, and certain writers and economists have subsequently attempted to co-ordinate these reports and establish the world position. The main weakness, however, of the papers which were presented to both Conferences lay in the fact that no standard method of investigation had been adopted, and the task of reconciling differences of standpoint and of treatment appeared to be insuperable.

It was felt, therefore, that, until this great initial difficulty was overcome, little real progress could be made in the formation of a reliable estimate of the world's power resources, and the International Executive Council of the World Power Conference decided that they should carry out this work as one of their most important and certainly one of their most valuable activities. They decided that a survey of existing information should be carried out; all the relevant statistics should be collected with a view to presenting a fairly complete picture of the work that had actually been done, while a bibliography should be compiled of the principal publications, studies and articles which had appeared in the leading countries since 1924.

When this survey had been carried out, it might be possible for co-operative action to be taken by the main countries along certain lines which the survey would possibly indicate, and the vast work of assessing the power resources of the world on a genuinely comparable basis be initiated. This survey has now been carried out and is published in the present Monograph.

Even the most cursory perusal of the material which has been collected will show how vast the range of the subject is and how much has actually been done which, if properly co-ordinated, might well have been of the very greatest possible value for the economic development of the world, but it is precisely this work of co-ordination which presents the greatest difficulties. Territorial changes caused by the War have been in themselves a factor retarding co-ordination, while there seems to be no unanimity regarding either the definition of resources or the methods of assessment.

Even so, the information given regarding the world's resources in hard coal, brown coal, oil and water-power is almost in itself sufficient to allow us to distinguish between countries which have immense resources at present being adequately utilised, such as the United States, and countries with equally immense resources which are practically virgin. When one

considers that industrial development, under present conditions, depends on the use of power in manufacturing processes, and that power generation depends on coal in its various forms, oil or water-power, one has, in the knowledge of the world distribution of such resources, a key to the future alignment of economic values and the future economic prosperity of the world as a whole.

For obvious reasons, no attempt has been made to assess the world reserves of what may be regarded as inexhaustible power-producing materials, such as the wind, the tide, solar energy, timber and all vegetable products capable of yielding alcohol. All these can be perpetually renewed and are beyond all possibility of exhaustion, since, of course, in the case of vegetable products, the world's resources can be extended or decreased at the will of man, and the growth of invention may serve in the future to add enormously to their value. Any attempt made to assess the value of such reserves would be entirely speculative and would be subject to perpetual correction. In themselves they play at present a part of practically no importance in the power situation.

In addition to the assessment of power resources, the Monograph has given in very full detail world production in the leading sources of energy, such as hard coal, brown coal, coke, oil, gas, water-power, while the state of electrical development in twenty-four countries in 1927 is shown. A still further development of recent origin has lain in the preparation of statistics of electrical power production by six of the leading countries, responsible for 62 per cent. of the world's output on a monthly basis. In a final section, the total power production of the world during 1927 on a common basis has been calculated, so that it is possible to understand very clearly the part played by each source of energy, the percentage of world power production represented by water-power, for example, as compared with coal.

The statistics given in the Monograph may be subject to modification and adjustment as fuller information becomes

available, since no single country has regarded the compilation of essential information bearing on power as a particularly important function. If, through co-operative action, it is possible to fill up the gaps in our knowledge, and thus render it possible for us to draw up finally a complete and exhaustive and internationally comparable power survey, then the enterprise of the International Executive Council of the World Power Conference in authorising the present survey will have been more than justified. At a time when great industrial countries, in the possession of vast financial reserves, are still in ignorance of how best to use those reserves and ensure a continuous demand for their products, a survey of the power resources and power production of the world is a matter of urgent importance. It has more than a technical or scientific significance; its justification is primarily economic, and it should render it possible for concerted action to be taken with a view to developing on a scientific basis countries which have been hitherto undeveloped. The exchange of information of this type, while it renders international relations much more cordial and brings the main industrial countries into closer union in a work of great potential economic significance, must be of benefit to every country engaged in this work, and it is in the hope that such international co-operation will result that the International Executive Council of the World Power Conference has published this Monograph.

D. N. DUNLOP,

Chairman,

International Executive Council.

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A study of the power resources of the world, if it pretended to be at all thorough, would entail immense labour which, at the end, might not be entirely satisfactory. In the first place, no reliable method has yet been discovered of assessing the economic or even technical value of such resources as have been already surveyed. There is no standard definition of bituminous coal, for example, which will cover the circumstance that calorific values may fluctuate within comparatively wide limits. We may have ranked as bituminous a coal with only a calorific value of 8,500 B.Th.U. per pound and, in the same class, a coal giving 13,500 B.Th.U. There are virtually no absolutes in the assessment of power beyond, of course, physical units such as B.Th.U. and kilowatt hours. Even the definition of water power suffers from geographical and geological variations, which render it exceedingly difficult to bring one country into a direct line of comparison with another. Again, the state of our knowledge is such that we cannot say with any approach to truth that oil reserves represent a given volume. The course of exploration is continuous, and technical developments may be such as to bring an entirely new range of natural products into consideration as potential oil resources.

It is possible to adduce other considerations which, taken together, may serve to discredit any effort made to assess the world's resources in anything. Yet such an assessment, however fragmentary and irrelevant it may appear, has its value. It imposes some limit to conjecture and acts as a basis for measuring tentatively what has been achieved and what may be achieved in safety.

It applies some approach to a definition where previously lay the unknown; it may serve to guide the course of scientific investigation and show very approximately the inter-relations between one form of energy and another. It furnishes also a background against which progress in production and consumption may be measured, and indicates when a critical movement has intervened or will intervene. It has also one important economic function; it allows us to form some classification between countries which is essentially economic. We can discover those countries, which, although possessed of enormous potentialities, have not been developed, and those countries, in turn, which are already so highly developed that little rapid progress may be expected from them in the future. Through this knowledge, effort may be concentrated on developments in the more backward countries, which have a direct significance for the economic prosperity of the world, and lead in this way to the realisation of a higher standard of industrial and general economic prosperity.

One must make a clear distinction between power resources which can be indefinitely prolonged, either through reproduction or through substitution, and those resources which are already fixed in the world and can only be increased through the discovery of new territories containing them. In the first category should be placed such resources as timber and all vegetable products yielding alcohol and other liquid products capable of being used as power agents. With them also should be classified such forces as wind, the tide, and solar energy. These are perpetually renewed and beyond all possibility of exhaustion. In the case of vegetable products, the world's resources can be expanded or decreased at the will of man, and the growth of invention may serve in the future to add enormously to their value. In the second category should be placed coal in its various forms, including peat, oil shales, mineral oil and natural gas. In each of the latter, the resources are already part of the composition of the earth and are capable, therefore, of ultimate exhaustion.

In a third category should be placed water power, in the sense that it belongs both to the first and the second. Water power resources are limited by the natural configuration of the various countries of the world, and they can only be increased by the use of reservoirs and by a linking up of watersheds to supply the maximum volume of power to hydro-electric plants. Yet, since water itself is not limited in nature and is perpetually renewed,

these power plants may continue in operation to all eternity, the limitation in this case being largely geographical and technical.

In this monograph, we have decided to omit the first category altogether as being beyond computation. Even if a survey were made on a purely territorial basis of the areas which could be used for timber and the production of vegetable products capable of yielding motor oils, such a survey could only have an academic value, owing to the fact that power produced from these resources would not be able to justify itself on an economic basis against power produced from the resources in the second category. Research and development may open up possibilities in this direction, but it would be confusing the issues to devote any attention now to them. This monograph is confined, therefore, to the consideration of coal resources, water power and oil.

In each case, we have not confined attention purely to consideration of reserves alone, but have dealt with production as far as the most recent statistics are available. Production does afford some indication of the world demand for power-generating materials and, in the case of oil, is the only reliable information available. It is generally agreed that all estimates of oil reserves hitherto made are only conjectural and, in one or two countries, have been so far wrong in the past that the total production already marketed exceeds the total reserves estimated, without any real indication of approaching exhaustion.

Again, in electricity, we have shown the relations between the energy actually utilised in water-power plants and the potential energy, with an indication also of the total capacity of all generating plant using oil or coal or water as a main fuel or motive force. Finally, we have reduced the world's production in the various power products to a common calorific basis and shown, with reference to this, what may be regarded as the world's power consumption at a given time. Such a calculation should have some value as showing the range of expansion open to any one form of power.

Thus, it has been stated that the growth of water power and oil has reduced the world demand for coal, with, however, a compensating circumstance in the increase of steam-generated electricity, while the growth of coal distillation, represented to some extent by the world production of coke, has served also to widen the market for coal and counteract, to some extent, the decline which apparently is taking place in the demand for it.

One main function of the monograph has already been indicated—namely, that of co-ordinating all the information there is available on the subject, but a still more important function lies in indicating inequalities and omissions in the various systems and methods adopted for assessing power resources. There is no doubt that before a moderately reliable estimate can be prepared, there must be standard methods adopted in every country for investigating and determining power resources. It is only after one method has been agreed among the principal countries of the world and definitely adopted that we shall come within sight of a world survey of more than academic or speculative interest.

SECTION I

GENERAL CONSIDERATIONS

SECTION I

GENERAL CONSIDERATIONS

WORLD POWER RESOURCES ACCORDING TO ARRHENIUS—STEINMETZ—ESTIMATES BASED ON WORLD POWER CONFERENCE OF 1924—COAL RESOURCES—WATER POWER RESOURCES—DISCREPANCY BETWEEN ESTIMATES—COMPILATION BY J. W. MEARES—OIL RESOURCES—STATEMENT BY DR. EGLOFF.

Several estimates have been made of the total energy available in the world from all possible sources, including solar irradiation, but they have, of course, only an academic interest. Professor Svante Arrhenius, in a series of articles delivered at Dantzig in 1922, gave the following sources of energy :—

TABLE I

		Billion Calories
1.	Solar radiation of heat during the year	$3 \times 10^{12} \times 10^{6}$
2.	Solar radiation of heat to earth, including air jacket ...	1330×10^{6}
3.	Solar radiation of heat to the surface of the earth ...	530×10^{6}
4.	Evaporation of water in the oceans and air	340×10^{6}
5.	Energy of the water in the clouds	2800×10^{6}
6.	Energy of the flowing water	55,000
7.	Energy realisable from rivers	4,000
8.	Energy of the air currents	33×10^{6}
9.	Energy stored up in plants	160,000
10.	Energy of the coal consumed per annum	10,000
11.	Total energy of fossil coal	44×10^{6}
12.	Total energy of earth oil deposits	120,000

Only four of the sources mentioned here can be considered at all, in spite of the fact that several calculations have been made regarding the generation of energy from the heat of the sun and the sea at the Equator. These four sources are power energy derived from rivers, from coal, from oil, and from the air. In time, it may be possible for tidal energy to be captured, and a number of experimental installations have already been carried out to this end, but the success of such a system depends on a favourable land configuration, with the possibility of exact co-ordination between the tides during all the year. In this country, the Severn scheme has

been debated for a number of years, and recently the possibility of developing a tidal power system on the coast of Essex was also investigated, while in France work has been going on on the coast of Brittany with the same end in view. The calculation of tidal energy is not, therefore, a simple matter of the rise and fall of the tides with calculation of the total energy available from such movements. It is rather an examination of suitable territorial conditions which will allow the tides to be harnessed, and in this direction little has been done.*

A further example of calculations very similar to those carried out by Professor Arrhenius can be found in a lecture delivered by Steinmetz in 1917, but Steinmetz assumed at once that the only two sources of energy that really counted in the modern industrial complex were coal, with its allied products—oil, natural gas, etc.—and water power. According to him, the total coal consumption of 867 million tons in 1918 would correspond to a total generating plant capacity of 867 million kilowatt years, working on a thermal efficiency of 100 per cent., but, since the average thermal efficiency of generating plant was only about 10 per cent., this coal consumption would only yield about 87 million kW.

Similarly, he gives the total potential water-power at 380 million kW. with an efficiency of 100 per cent.; adopting, however, a commercial efficiency of 60 per cent., the power available amounts to 230 million kW. This represents more or less the absolute maximum and could never conceivably be reached. In the question of solar energy estimated from the solar radiation at the earth's surface, a total of about 800,000 million kW. could be generated if under a régime of immense scientific development this energy could ever be caught.

All these calculations are interesting as an indication of methods and of modes of thought, but they do not lead us into practical politics. There is no means of testing any of the calculations made by Professor Arrhenius, while the technical development of generating plant in the United States has long since made the estimate of 10 per cent. thermal efficiency, made by Professor Steinmetz in 1917, hopelessly out of date. A more correct figure would now come closer to 18 per cent.

As a result of the World Power Conference of 1924, a number of

* An article by A. de Rouville entitled "L'utilizzazione dell'energia marina" (*Energia Elettrica*, June, 1928, pp. 698-710), gives perhaps the best survey of the present state of knowledge regarding tidal energy.

articles and special studies summarising the statistics given at the Conference were published. We find, for example, two articles which were published in the German press—one by Dr. van Heys ("Technik und Wirtschaft," 1924, Nos. 10-11), and the second by H. von Glinski (Z.V.D.I.," February 7 and 14, 1925). In this case, taking these articles together, we find the world coal resources given as follows :—

TABLE II
(Thousand Million Tons)

Continent	Toronto Geological Congress 1913	World Power Conference Papers	Estimate of Van Heys
Europe	784	1,067	1,100
America	5,106	3,254	4,700
Asia	1,280	1,281	2,700
Australia	170	170	500
Africa	58	63	1,800
World Total ...	7,400	5,835	10,800

The difference shown in these three estimates are such that one can hardly attach importance to any of them, and it is scarcely sufficient to say that the coal resources of the world lie between 5,835,000 million tons and 10,800,000 million tons. The range is much too wide to allow any of these calculations to be of value.

Again, the same author, Van Heys, gives the world's water-power resources as follows :—

TABLE III

Continent	Technik und Wirtschaft	World Power Conference	Estimate of Van Heys
	(In Million H.P.)		
Europe	100	131	136
Asia	236	145	490
Africa	160	6·2	204
Australia	30	8·6	69
America	386	90	584
World Total ...	912	380·8	1,483

In this case again, the range of estimates is much too wide. The World Power Conference Papers give 373,000,000 H.P., the German source 912,000,000 H.P., and Van Heys 1,483,000,000 H.P. The discrepancy here is too great to allow any one set of

figures to be accepted. A fourth estimate, made by J. W. Meares ("World Power," January, 1925), fixed the total world resources at 138,000,000 kW. on a 90 per cent. availability and unity load factor. This estimate was challenged by a number of authorities, with the result that a state of almost complete indecision exists regarding the whole question.

With reference to oil resources, certain estimates have been published and promptly repudiated. In the case of the United States especially, such estimates have been shown repeatedly to be entirely inadequate. Thus it is sufficient to quote from a paper submitted to the Fuel Conference of the World Power Conference in 1928 by Dr. Gustav Egloff, who says :—

"The total amount of crude oil in the earth's crust is unknown, and unestimated, but it is certainly an astonishing volume. Geologists state that oil discovery is a possibility in 1,100,000,000 acres in the United States alone, or 56 per cent. of its total land area. The contrast of this huge territory with the 2,000,000 acres producing oil at the present time, makes it certain that new fields will be continually discovered and that the oil of that country will prove ample for many years to come. What is true regarding the potential oil production of the United States probably is true in even greater measure for many of the other countries of the world where oil exploration has been even less thorough than in the United States.

From the beginning of production on a significant scale in the year 1857 to the end of 1927, the oil-fields of the world produced 16,000,000,000 barrels of petroleum. This is, however, only a fraction of the oil resources of the producing areas, for it is estimated that at the most 20 per cent. of the oil in the ground is brought to the surface by present methods of recovery. For every barrel of oil produced at least four barrels remain in the earth. While 16,000,000,000 barrels of oil have been produced, 64,000,000,000 barrels or more are still in the oil sands. This oil alone, could it be recovered by means of flooding, repressuring or mining, would supply the world's needs for over fifty years.

Since the foundation of the petroleum industry, many predictions of oil shortage have been made. But despite the stupendous increase in the use of petroleum during the last two decades, discovery of new fields has never failed to keep pace with the demand. At the present time the world's output of oil is far

Countr
EUROPE
Great Britain
Ireland
Sweden
Norway
Denmark
Netherlands
France
Russia
Austria
Hungary
Germany
Switzerland
Spain
Esthonia
Belgium
Finland
Czecho-Slovak
Italy ..
Poland
Greece
Turkey, etc.
AFRICA
Southern Rho
South Africa
East Africa
Rest of Africa
AMERIC
United States
Canada-
British Colu
Alberta
Saskatchewa
Manitoba
Ontario
Quebec
New Brunswi
Nova Scotia
Prince Edwa
Yukon and N
Mexico
British Guian
Rest of S. Am
Central Ameri
ASIA
Indian Empir

> below the capacity of the actual producing wells. Proration and drilling agreements are holding back a veritable flood of crude, which could be produced in amounts far exceeding present requirements. In view of the known crude oil reserves, the vast amount left underground by present production methods, and the undiscovered fields that no doubt exist, an oil shortage is far in the future."

It is evident from the information given above that no reliable estimate has really been made of the power resources of the world, either taken as a whole or sectionalised, and the best one can do is to make a survey of the most reliable existing sources of information and, by combining them, arrive at some preliminary estimate which may serve to even out some of the most glaring inequalities between the estimates already made.

SECTION II

HARD COAL, BROWN COAL, GAS, AND OIL

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HARD COAL, BROWN COAL, GAS, AND OIL

TORONTO GEOLOGICAL CONGRESS—TERRITORIAL CHANGES CAUSED BY THE WAR—CORRECTING THE TORONTO ESTIMATES—COAL RESOURCES OF FRANCE, CANADA, GERMANY, HOLLAND, AUSTRIA, CZECHO-SLOVAKIA, POLAND, HUNGARY, ROUMANIA, RUSSIA, CHINA, SPITZBERGEN, INDIA, AUSTRALIA, SOUTH AFRICA, NEW ZEALAND, COLOMBIA, CHILE, UNITED STATES. WORLD PRODUCTION OF COAL, BROWN COAL, AND COKE (1913-1927)—NATURAL GAS AND WASTE HEAT, AMERICAN STATISTICS—OIL RESOURCES AND PRODUCTION OF THE WORLD—AN ESTIMATE OF RESOURCES—TECHNICAL DIFFICULTIES—DANGER OF ATTEMPTING SURVEY.

If we deal with coal first, we find that the Toronto Congress of 1913 made the first estimate of the world's coal resources, the three main divisions being anthracite coals, bituminous coals, and sub-bituminous coals, brown coals, and lignites. A number of countries made a further distinction between reserves actually surveyed, possible reserves and potential reserves, the first two categories being based on a depth of 1,000 metres, and the last on the depth of 1,000-2,000 metres. The results of the Toronto Congress were published by Sir Richard Redmayne in a paper he submitted to the 1924 World Power Conference on the coal resources of the world, and they are given in the following table:

Since 1913 no attempt has been made to carry out a second world survey of coal resources, but a number of countries have gone into the subject much more carefully, and their findings were either published in a number of papers submitted to the World Power Conference, or in a number of documents of an official nature surveying certain territories. Again, the incidence of the war destroyed many of the old territorial divisions. Thus Austria and Hungary, as defined in the Geological Congress Reports, have

ceased to exist. The whole of Central Europe has changed its political boundaries, while Russia has been narrowed in area by the loss of the Baltic States and Finland. For this reason alone, it would be necessary to carry out a new survey.

TABLE V

COAL RESERVES OF THE WORLD

I. COAL RESERVES OF NORTH AMERICA

(In Million Metric Tons)

Country	Class of Coal			Totals	
	Anthracite coals	Bituminous coals	Sub-bituminous coals, brown coals and lignites		
Newfoundland ...		500			500
Canada—					
Nova Scotia ...		9,649			
		70		9,719	
New Brunswick ...		151		151	
Ontario			25	25	
Manitoba			160	160	
Saskatchewan ...			57,400	57,400	
Alberta	768	198,092	876,179	1,075,039	
British Columbia...	1,350	67,689	5,196	76,035	
		1,800			
Yukon	40	210	4,690	4,940	
N.W. Territories ...			4,800	4,800	
Arctic Islands ...		6,000		6,000	
	2,158	283,661	948,450		1,234,269
United States—					
Eastern Fields ...	16,906	494,454		511,360	
Interior Fields ...	363	478,232		478,595	
Gulf Fields ...			20,952	20,952	
Northern Plains ...		41,106	1,134,000	1,175,106	
Mountains & Coast	484	335,460	692,207	1,028,151	
Coal deeply covered		604,900		604,900	
Alaska	1,931	1,369	16,293	19,593	
	19,684	1,955,521	1,863,452		3,838,657
Mexico; no estimate					
Honduras		1	4		5
Total Estimate for North America	21,842	2,239,683	2,811,906		5,073,431

II. COAL RESERVES OF EUROPE

(In Million Metric Tons)

Country	Class of Coal			Totals	
	Anthracite coals	Bituminous coals	Sub-bituminous coals, brown coals and lignites		
Great Britain and Ireland—					
England		125,899		125,899	
Wales	8,685	31,597		40,282	
Scotland	2,500	20,561		23,061	
Ireland	172	119		291	
	11,357	178,176			189,533
Portugal	20				20
Spain—					
Asturias	1,156	2,312 2,312		5,780	
Other Fields ...	479	925 817	767	2,988	
	1,635	6,366	767		8,768
France—					
North of Ardennes Massif.	2,210	8,860 1,090		12,160	
Eastern		16 630		646	
Armorican Massif.	7	26		33	
Central Massif. ...	949	1,312 746		3,007	
Alps	105			105	
Lignite Areas ...			1,632	1,632	
	3,271	12,680	1,632		17,583
Italy	144		99		243
Greece			40		40
Bulgaria		30	358		388
Denmark			50		50
Netherlands					
S. Limburg ...	195	1,857 320		2,372	
S. Peel	125	1,640 265		2,030	
	320	4,082			4,402

II. COAL RESERVES OF EUROPE (*Continued*)

(In Million Metric Tons)

Country	Class of Coal: Anthracite coals	Class of Coal: Bituminous coals	Class of Coal: Sub-bituminous coals, brown coals and lignites	Totals	
Belgium—					
Campine—					
Limbourg ...		7,000			
D'Anvers ...		1,000			
Namur		3,000			
		11,000			11,000
Germany—					
Saar		16,548		16,548	
Westphalia ...		213,566		213,566	
L. Silesia		2,944		2,944	
U. Silesia ...		165,987		165,987	
Saxony		225	3,000	3,225	
Left of Rhine ...		10,458		10,458	
Other districts ...		247		247	
N. German States			9,745	9,745	
Bavaria			368	368	
Hesse			268	268	
		409,975	13,381		423,356
Hungary—					
Carboniferous ...		3		3	
Liassic		110	25	135	
Cretaceous ...			3	3	
Tertiary			1,444	1,444	
Neo-Tertiary ...			132	132	
		113	1,604		1,717
Austria—					
Alpine Regions ...		10	460	470	
Tertiary Lowlands			250	250	
Bohemia, Silesia and Galicia ...		28,377	12,170	40,547	
Dalmatia			14	14	
Deep Measures ...		12,595		12,595	
		40,982	12,894		53,876
Bosnia & Herzegovina—					
Triassic			1		
Oligocene-Miocene			1,325		
Pliocene			2,350		
			3,676		3,676

II. COAL RESERVES OF EUROPE (*Continued*)
(In Million Metric Tons)

Country	Class of Coal: Anthracite coals	Class of Coal: Bituminous coals	Class of Coal: Sub-bituminous coals, brown coals and lignites	Totals	
Servia		45	484		529
Roumania			39		39
Sweden		114			114
Russia—					
Dombrova ...		2,525		2,525	
Moscow			1,578	1,578	
Donetz	37,599	18,014		55,613	
S.W. Russia ...			43	43	
W. Urals ...		57		57	
Caucasus		253	37	290	
	37,599	20,849	1,658		60,106
Spitzbergen ...		8,750			8,750
Total Estimate for Europe	54,346	693,162	36,682		784,190

III. COAL RESERVES OF ASIA
(In Million Metric Tons)

Country	Class of Coal: Anthracite coals	Class of Coal: Bituminous coals	Class of Coal: Sub-bituminous coals, brown coals and lignites	Totals	
Corea	40	5 9	27		
	40	14	27		81
China—					
Chili	10,027	11,691 950		22,668	
Shantung	2,000	5,083		7,083	
Shansi	300,000	414,340		714,340	
Shensi		1,050		1,050	
Kansu		5,129		5,129	
Honan	6,575	2,700		9,275	
Kiangsu	10			10	
Anhui		187		187	
Hupei		117		117	
Chekiang	18	126		144	

III. COAL RESERVES OF ASIA (*Continued*)

(In Million Metric Tons)

Country	Class of Coal			Totals	
	Anthracite coals	Bituminous coals	Sub-bituminous coals, brown coals and lignites		
Kiangsi		3,395		3,345	
Fukien	80			80	
Kuantung ...	754	255		1,009	
Kuangsi		500		500	
Hunan	48,000	42,000		90,000	
Szechuan	20,000	60,000	500	80,500	
Kueichou		30,000		30,000	
Yunnan		30,000	100	30,100	
	387,464	607,523	600		995,587
Japan— Mesozoic coal ...	41	5 5		51	
Tertiary coal— Karafuto		1,362		362	
Hokkaido		2,442	233	2,675	
Honsu	21	15	545	581	
Kyushu		2,916		2,916	
Taiwan		385		385	
	62	7,130	778		7,970
Manchuria ...	68	254 886			
	68	1,140			1,208
Siberia	1	66,034	107,844		173,879
Indo-China ...	20,002				20,002
India— Bengal, Behar Orissa		53,085 210		53,295	
Central India ...		22,657		22,657	
Central Provinces		270 30	2,549	2,849	
Northern Province		147	53	200	
		76,399	2,602		79,001
Persia		1,858			1,858
Total Estimate for Asia ...	407,637	760,098	111,851		1,279,586

IV. COAL RESERVES OF OCEANIA
(In Million Metric Tons)

Country	Class of Coal: Anthracite coals	Class of Coal: Bituminous coals	Class of Coal: Sub-bituminous coals, brown coals and lignites	Totals	
Australia—					
New South Wales		118,439		118,439	
Victoria		52	31,144	31,196	
Queensland ...	659	12,777	866		
		916		15,218	
Tasmania		65			
		1		66	
W. Australia ...			653	653	
	659	132,250	32,663		165,572
New Zealand ...		125	2,475		
		786			3,386
British N. Borneo ...		75			75
Netherlands India		240	1,071		1,311
Philippines ...		5	61		66
Total Estimate for Oceania ...	659	133,481	36,270		170,410

V. COAL RESERVES OF AFRICA
(In Million Metric Tons)

Country	Class of Coal: Anthracite coals	Class of Coal: Bituminous coals	Class of Coal: Sub-bituminous coals, brown coals and lignites	Totals	
Belgian Congo ...		90	900		990
Southern Nigeria ...			80		80
Rhodesia	22	B 425	74		
		C 68			569
South Africa—					
Transvaal		B 28,800			
		C 7,200		36,000	
Natal	4,700	4,700		9,400	
Zululand	6,000			6,000	
Orange Free State, Cape, Basutoland		B 2,880			
Swaziland ...	960	C 960		4,800	
	11,660	44,540			56,200
Total Estimate for Africa ...	11,662	45,123	1,054		57,839

VI. COAL RESERVES OF SOUTH AMERICA

(In Million Metric Tons)

Country	Class of Coal			Totals	
	Anthracite coals	Bituminous coals	Sub-bituminous coals, brown coals and lignites		
Colombia		27,000		27,000	
Venezuela		5		5	
Peru	700	1,339		2,039	
Argentina		5		5	
Chili...		3,048		3,048	
Total Estimate for South America	700	31,397			32,097

COAL RESERVES OF THE WORLD

RECAPITULATION

(In Million Metric Tons)

	Class of Coal			Totals	
	Anthracite coals	Bituminous coals	Sub-bituminous coals, brown coals and lignites		
North America ...	21,842	2,239,683	2,811,906		5,073,431
Europe	54,346	693,162	36,682		784,190
Asia	407,637	760,098	111,851		1,279,586
Oceanic	659	133,481	36,270		170,410
Africa	11,662	45,123	1,054		57,839
South America ...	700	31,397			32,097
Total	496,846	3,902,944	2,997,763		7,397,553

Unestimated reserves are known in Mexico, Switzerland, Denmark, Iceland, Norway, Montenegro, Turkey, Siberia, Malay States, Siam, Asia Minor, Ecuador, Bolivia, Brazil, and on the Antarctic Continent.

Brown coal not included in the estimate is found in Oceania, South America and in the Arctic Regions.

It is impossible at this stage to gather together statistics of the world's coal resources which would have even the authoritative character of those submitted to the Toronto Congress. All that we can do is to take a number of countries, regarding which more recent information is available, and carry the survey through those countries without attempting to reach a world total. The main weakness of the Toronto Congress figures is this: there is little real distinction made between the coal reserves actually surveyed and those which are possible or potential, and there is little unanimity regarding the depth to which investigation should be carried. It is obvious, however, that the only reliable statistics that should be considered in this connection are those of reserves actually surveyed, and they, of course, represent a comparatively small fraction of the total resources given at the Congress.

Thus, if we take two countries widely separated, France and Canada, we obtain the following figures:—

TABLE VI

COAL RESOURCES OF FRANCE

A. BY CLASS OF COAL

(In Millions of Tons)

Class of Coal	Reserves at depth of less than 1,200 metres				Possible Reserves at depth of 1,200-1,800 m.	General Total
	Ascertained	Probable	Possible	Total		
Anthracite with less than 7% volatiles	2·5	4·5	115·0	122·0	—	122·0
Anthracite with 7-12% volatiles...	578·6	922·4	1,108·7	2,609·7	540·0	3,149·7
Semi-bituminous with 12-17% volatiles	679·3	658·1	1,342·3	2,679·7	860·0	3,539·7
Coking Coal with 17-26% volatiles	1,094·2	1,123·7	864·7	3,082·6	950·0	4,032·6
Bituminous proper with 26-32% volatiles ...	1,064·1	662·6	625·0	2,351·7	290·0	2,641·7
Gas Coal with more than 32% volatiles	784·6	522·3	830·0	2,136·9	330·0	2,466·9
Total Coal ...	4,203·3	3,893·6	4,885·7	12,982·6	2,970·0	15,952·6
Lignites ...	301·0	410·2	920·8	1,632·0	...	1,632·0
General Totals ...	4,504·3	4,303·8	5,806·5	14,614·6	2,970·0	17,584·6

B. By Region

(In Millions of Tons)

Region	Reserves at depth of less than 1,200 metres				Possible Reserves at depth of 1,200-1,800 m.	General Total
	Ascertained	Probable	Possible	Total		
Nord et Pas-de-Calais (Valenciennes) ...	3,790·0	3,010·0	2,720·0	9,520·0	2,580·0	12,100·00
Loire	316·35	275·4	285·0	696·75	90·0	786·75
Gard	73·5	370·6	515·7	959·8	...	959·8
Bourgogne et Nivernais ...	65·0	111·3	584·0	760·3	...	760·3
Tarn et Aveyron	92·1	51·0	171·0	314·1	...	314·1
Other Regions ...	347·35	485·5	1,530·8	2,363·65	300·0	2,663·65
Total	4,504·3	4,303·8	5,806·5	14,614·6	2,970·0	17,584·60

In the case of France, the reserves actually surveyed were less than a third of the totals given, while, in Canada, the actual reserve formed only half of the total, including probable and potential resources.

TABLE VII

COAL RESOURCES OF CANADA, BY PROVINCES AND CLASSES OF COAL*

(In metric tons of 2,204 lb.)

Provinces or Districts	Including seams of 1 ft. or over to a depth of 4,000 ft.					Including seams of 2 ft. and over at depths between 4,000 and 6,000 ft.	
	Actual Reserve			Probable Reserve		Probable Reserve	
	Calculation based on actual thickness and extent			Approximate Estimate		Approximate Estimate	
	Area sq. miles	Class of Coal†	Thousands of Tons	Area sq. miles	Thousands of tons	Area sq. miles	Thousands of tons
Nova Scotia	174	B	2,188,151	204	4,911,817	73	2,639,000
New Brunswick	—	B	—	121	151,000	—	—
Ontario ..	—	L	—	10	25,000	—	—
Manitoba ..	—	L	—	48	160,000	—	—
Saskatchewan	306	L	2,412,000	13,100	57,400,000	—	—
Alberta ..	25,300	L	382,500,000	56,375	491,271,000	203	12,700,000
		B	3,223,800		182,183,600		
		A & B	669,000		100,000		
British Columbia ..	439	A & B	23,771,242	6,196	44,907,700	11	2,160,000
		L	60,000		5,136,000		
Yukon ..		A & B	—	2,840	250,000	—	—
		L	—		4,690,000	—	—
North-West Territories..	—	L	—	300	4,800,000	—	—
Arctic Islands	—	B	—	6,000	6,000,000	—	—
Total ..	26,219	..	414,804,193††	85,194	801,986,117	287	17,499,000

*See "Coal, Coke and By-Products," published by the Imperial Mineral Resources Bureau.
†A=Anthracite; B=Bituminous; L=Lignite.
††The coal of all classes mined in Alberta to 1911, amounting to 20,000,000 tons, has been deducted.

Again, we find the Prussian Geological Intitute defining the certain coal resources of Germany as follows :—

TABLE VIII

COAL RESOURCES OF GERMANY

Hard Coal	Million Tons
West Upper Silesia	10,900
Lower Silesia	1,240
Free State of Saxony Province of Saxony	230
Hanover	250
Ruhr	55,100
North Crefeld Area	7,100
Brüggen-Erkelenz Area	1,750
Aachen Area	1,570
Saar...	12,200
Brown Coal	
Lower Rhine Area	3,700
Westerwald	110
Upper Hesse	70
Lower Hesse	160
Braunschweig-Magdeburg Area	1,610
Thuringia-Saxony	8,660
Niederlausitz Area	5,220
Oberlausitz Area	1,530
Oder Area	470
Other Areas	370
Grand Total (Hard Coal and Brown Coal)	112,240
Grand Total (excluding Saar)	100,040

These estimates are only one-fourth of the total given at the Toronto Congress, which was 423,356,000,000 tons, but, while the hard coal resources given above—namely, 90,340,000,000 tons—are only 22 per cent. of those given at Toronto, the brown coal resources, 21,900,000,000 tons, are 64 per cent. higher.

The coal resources of Holland, according to a more recent survey than that of the Toronto Geological Congress, have been given as equivalent to 5,000,000,000 tons of bituminous coal, 3,000,000,000 tons being located in South Limburg, 1,800,000,000 tons in North Limburg and North Brabant and 200,000,000 tons in East Gelderland and East Oberijssel.

The coal resources of Austria in its present geographical position have been given as 16,000,000 tons of bituminous and 384,000,000 tons of sub-bituminous and lignites, yielding a grand total of 400,000,000 tons. In Czecho-Slovakia, the corresponding figures have been given as 8,787,200,000 tons of bituminous and sub-bituminous coals, and 12,434,000,000 tons of lignites, giving a grand total of 21,221,100,000 tons. The Polish statistics give a total for all types of coal as 43,010,000,000 tons, actual and probable resources, with an additional 18,871,000,000 tons possible

resources, equivalent to a grand total of 61,881,000,000 tons. In Hungary, with its new territorial limits, the total potential resources have been estimated at 118,600,000 tons of bituminous coal, 518,490,000 tons of brown coal, and 3,650,000 tons of lignite, giving a grand total of 640,740,000 tons. In Roumania, the most recent estimates give for bituminous coal 2,900,000 tons actually surveyed, with an additional 1,230,000 tons representing a probable reserve, or a total of 4,130,000 tons. In addition to this, lignites and sub-bituminous coals account for a total of about 26,000,000 tons.

Estimates of the coal resources of Russia and Siberia differ very widely, one set of statistics giving the remarkable total of 429,000,000,000 tons. This total is made up of 38,000,000,000 tons of anthracites, 379,000,000,000 tons of bituminous and sub-bituminous coals, and 12,000,000,000 tons of lignites. According to statistics published by the French *Comité des Forges,* the coal resources of Russia are spread over a number of basins, as follow :—

(1). The Moscow basin, with actual and probable reserves estimated at 78,000,000 tons. Practically this entire reserve belongs to the sub-bituminous category.

(2). The Ural basin, with reserves of 110,000,000 tons, also of the sub-bituminous type.

(3). The Caucasus, with 365,000,000 tons.

(4). The Turkistan, with 170,000,000 tons.

(5). The Irkutsk basin in Siberia, with 150,000,000,000 tons, mostly in the sub-bituminous category. It is estimated that not less than 1,500,000,000,000 tons represent the total possible and potential resources of Siberia.

(6). The Donetz basin, with total resources of 65,613,000,000 tons, of which 37,599,000,000 tons are anthracite and the remainder bituminous coal.

All these estimates must be regarded as purely tentative, since no completely detailed survey has been made of the territory.

A third estimate has been given by W. A. Obrutschew (Internationale Bergwirtschaft, February, 1926), where he gives the entire reserves of European Russia as 57,930,000,000 tons and of Siberia as 358,658,000,000 tons, or a total of 416,588,000,000 tons for both areas. The Siberian reserves are concentrated largely in seven basins :—Kusnez with 250,000,000,000 tons, Tocheremchowo, with 57,300,000,000 tons, Tungus with 35,000,000,000 tons, the Kirghiz Steppes with 4,160,000,000 tons, the Abakans basin

with 6,223,000,000 tons, the Chacharei with 2,700,000,000 tons, and Ekebaston with 500,000,000 tons. The Siberian anthracite reserves are given as only 37,100,000 tons, and brown coal, lignites, etc., as 3,544,000,000 tons. Some light on the distribution of the last-named is thrown by E. E. von Ahnert (Internationale Bergwirtschaft, July, 1928), who gives the brown coal reserves of areas actually surveyed in the Far East of Russia as 835,341,000 tons.

TABLE IX

BROWN COAL RESERVES OF FAR EASTERN RUSSIA

(Thousands of Tons)

Area or Province	Proved	Probable	Possible	Total
Trans-Caikal Regions ...	—	81,488	161,380	242,866
Amurland	—	187,500	214,400	401,900
North Ussuriland	25	7,500	26,250	33,775
South Ussuriland	9,395	11,913	128,664	154,800
North Saghalin	—	—	2,000	2,000
Total	9,420	288,401	532,694	835,341

The estimates carried out for the 1924 Conference regarding the coal resources of Spitzbergen and Bear Island give the resources of the latter as 200,000,000 tons of bituminous coals, and, of the former as 6,800,000,000 tons, 280,000,000 tons of which were culms, 1,500,000,000 tons cretaceous, 5,000,000,000 tons tertiary, with an additional 20,000,000 tons of undecided formation. These coals can scarcely be regarded as bituminous in the narrow sense of the definition; they tend more towards a lower grade type of coal.

In China, according to the Geological Survey concluded in 1926, the coal resources ascertained were as follows :—

TABLE X

COAL RESOURCES OF CHINA

(Millions of Tons)

Province	Anthracite	Bituminous	Lignite	Total
Chili	797	2,031	—	2,828
Fengsten	30	1,250	5	1,285
Jehol	20	473	167	660
Chakar & Suiyuan ...	150	310	—	460
Shansi	35,356	91,586	173	127,115
Hunan	5,842	1,607	—	7,449
Shantung	30	2,500	—	2,530
Anhui	70	288	—	358

TABLE X (*Continued*)
COAL RESOURCES OF CHINA
(Millions of Tons)

Province	Anthracite	Bituminous	Lignite	Total
Kuangsi	—	19,000	—	19,000
Kiangsu	110	785	—	895
Kukei	—	195	—	195
Chekiang	138	310	—	448
Heilungkiang ...	50	70	—	120
Kirin	—	344	23	367
Szechuan	—	6,000	—	6,000
Shensi	1,000	18,000	—	19,000
Yunnan	—	6,968	—	6,968
Kueichou	—	18,900	100	19,000
Kuantung	—	500	—	500
Fukien	—	150	—	150
Kansu	—	500	—	500
Total	43,593	173,465	568	217,626

In the British Dominions more recent figures have been available, above all for India, New Zealand and Australia. In India, the total coal resources are stated to be 79,992,500,000 tons; Bengal Behar and Orissa accounting for 54,295,000,000 tons, Central India for 22,672,000,000 tons, the Central Provinces for 270,000,000 tons of bituminous coals and 2,549,000,000 tons of sub-bituminous coals and lignites, Assam for 147,000,000 tons, Beluchistan for 45,000,000 tons, and other provinces for 14,500,000 tons, all of bituminous coals.

The coal resources of New Zealand, according to the Director of the Geological Survey, may be grouped in two classes, those actually proved and those surveyed.

TABLE XI
COAL RESOURCES OF NEW ZEALAND
(Millions of Tons)

Classification	Proved	Probable	Possible
Anthracite	Very little	Very little	Small
Bituminous	187	477	Moderate
Semi-bituminous ...	68	196	,,
Brown Coal	194	728	,,
Lignite	161	420	Large
Total	610	1,821	

The coal resources of Australia, as recorded in statistics published in the "Journal and Proceedings of the Royal Society of New South Wales in 1924," were estimated as follows:—

TABLE XII

COAL RESOURCES OF AUSTRALIA

(Millions of Tons)

State	Reserve	Probable Additional Reserve	Possible Additional Reserve
New South Wales ...	20,000		Very large, probably as much as 100,000
Queensland	410	1,684 (approx.)	13,000
Victoria	10,500		Not large
South Australia ...	50	No estimates	Moderately large
West Australia	3,500		Apparently not large
Tasmania	125	123	Do.
New Guinea		No estimates	
North Territory ...		Do.	
Total	34,585		

These statistics correspond fairly closely with the information given at the 1924 World Power Conference. Then it was stated that the total coal resources of New South Wales could be given as 26,000,000,000 tons, 7,500,000,000 tons of which belong to a first stage of development or survey, 11,500,000,000 tons to a second less definite, with a third potential class yielding 7,000,000,000 tons. South Australia was given as possessing 54,000,000 tons, largely of sub-bituminous coal. Otherwise there is no difference in the figures.

In South Africa, a detailed examination of a number of coalfields established reserves of bituminous coals as follow:—Witbank, 7,200,000,000 tons; South Rand, 7,314,000,000 tons; Vindeul-Delmas, 1,480,000,000 tons; Vaal, 760,000,000 tons; Springs, 542,000,000 tons; yielding a grand total of 17,296,000,000 tons. These resources are much smaller than the aggregates given by the Geological Toronto Congress for the various states of South Africa, but they only bear on individual coalfields and not on the entire area. In Southern Rhodesia, the coal resources were given

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in a more recent estimate as 6,800,000,000 tons, 15 per cent. of which was bituminous and 85 per cent. semi-bituminous.

In South America, geological surveys have been carried out in a number of the Republics, and in a recent report published in "Gluckauf" (August 25, 1928), on the tertiary coal deposits of Colombia, Dr. Scheibe describes the state of knowledge regarding the coal resources of that republic, but he makes no effort to assess the resources of the territory in definite terms. He gives the annual output of coal for Colombia as 220,000 tons, but he states quite specifically that the coal resources of Colombia, as given at the Toronto Geological Congress—namely, 27,000,000,000 tons—are excessively over-estimated. The Toronto Geological Congress based its estimates on the Provinces of Valle and Cauca, 20,000,000,000 tons; Cundinamarca and Boyaca, 6,000,000,000 tons; and Antioquia, 1,000,000,000 tons. A more recent investigation carried out by Dr. Grosse, and published in 1927, gives the resources of Antioquia as 2,500,000,000 tons down to a depth of 1,000 metres. In Chili, according to M. Lux ("Glückauf," May 28, 1927), the total coal resources lie in the vicinity of 200,000,000 tons, with a present annual production of about 2,000,000 tons. These resources represent known deposits, but they do not cover all the possible reserves available in the territory, regarding which no satisfactory information is available.

The coal resources of the United States, as given at the 1924 World Power Conference, are shown in Table XIII. Anthracite has not been included. There is room for a new statistical compilation giving all recent modifications and bringing the Toronto estimates up-to-date, but it would be inadvisable to do so until further information is available. We have indicated the principal countries regarding which more recent statistics have been prepared. They include the United States, Germany, Holland, Austria, Czecho-Slovakia, Hungary, Roumania, Russia, China, Spitzbergen and Bear Island, India, New Zealand, Australia, South Africa, Colombia and Chili.

Production

The hard coal, brown coal, and coke production of the world, over the periods 1913, 1921-27, has been compiled by the German State Coal Association for the consideration of the German State Coal Council, and we have decided to adopt their statistics in preference to all others. Examination of these statistics shows

TABLE XIII

ESTIMATED COAL RESERVES OF THE UNITED STATES, EXCLUSIVE OF ANTHRACITE, AND THEIR AVERAGE HEATING VALUES, EXPRESSED IN BRITISH THERMAL UNITS

State	Lignite		Sub-bituminous		Bituminous		Semi-bituminous	
	Short Tons	B.T.U.	Short Tons	B.T.U.	Short Tons	B.T.U.	Short Tons	B.T.U.
Alabama	—	—	—	—	35,582,000,000	13,500	—	—
Arkansas	60,000,000	6,000	—	—	90,700,000	13,500	854,800,000	13,500
Arizona	—	—	761,000,000	10,500	6,700,000	11,000	—	—
California	—	—	7,000,000	9,000	18,000,000	11,600	—	—
Colorado	—	—	69,430,000,000	9,800	141,980,000,000	12,100	—	—
Georgia	—	—	—	—	—	—	300,000,000	14,000
Idaho	—	—	60,000,000	8,500	300,000,000	12,200	—	—
Illinois	—	—	—	—	122,021,000,000	11,600	—	—
Indiana	—	—	—	—	34,724,000,000	11,400	—	—
Iowa	—	—	—	—	14,477,700,000	10,700	—	—
Kansas	—	—	—	—	19,755,000,000	12,500	—	—
Kentucky	—	—	—	—	81,561,000,000	13,200	—	—
Maryland	—	—	—	—	1,005,000,000	13,000	4,094,700,000	14,00
Michigan	—	—	—	—	1,000,000,000	11,700	—	—
Missouri	—	—	—	—	42,000,000,000	11,000	—	—
Montana	200,000,000,000	6,200	32,000,000,000	9,000	1,895,000,000	10,700	—	—
New Mexico	—	—	115,250,000,000	11,000	11,840,000,000	12,000	—	—
North Carolina	—	—	—	—	56,000,000	13,700	—	—
North Dakota	400,000,000,000	6,300	—	—	61,272,000,000	12,500	—	—
Ohio	—	—	—	—	31,171,000,000	13,200	4,000,000,000	13,400
Oklahoma	—	—	—	—	—	—	—	—
Oregon	—	—	3,000,000,000	8,200	1,500,000,000	8,400	—	—
Pennsylvania	—	—	—	—	35,230,800,000	13,500	8,624,980,000	14,000
South Dakota	400,000,000	6,000	—	—	—	—	—	—
Tennessee	—	—	—	—	16,886,000,000	13,400	—	—
Texas	15,300,000,000	7,000	—	—	5,941,000,000	12,000	—	—
Utah	—	—	2,500,000,000	10,600	64,080,000,000	12,800	—	—
Virginia	—	—	—	—	19,050,000,000	13,800	264,500,000	14,500
Washington	—	—	26,000,000,000	8,500	7,484,000,000	11,400	—	—
West Virginia	—	—	—	—	94,214,000,000	13,500	18,764,000,000	14,500
Wyoming	—	—	393,160,000,000	9,500	53,563,000,000	12,000	—	—
Totals	615,760,000,000		642,168,000,000		898,703,900,000		36,902,980,000	

Available lignite equivalent to	276,420,000,000	tons of coal of 14,000 B.Th.U.
Available sub-bituminous coal equivalent to	446,560,000,000	tons of coal of 14,000 B.Th.U.
Available bituminous coal equivalent to	799,238,000,000	tons of coal of 14,000 B.Th.U.
Available semi-bituminous coal equivalent to	37,380,600,000	tons of coal of 14,000 B.Th.U.
Total	1,559,598,600,000	

The short ton (2,000 pounds=907 kilograms) is used throughout this statement.

[*To face p.* 30.

EURO
Engla
Germ
Saar,
Silesi
Lorra
Saar
Palat
Uppe
Alsac
Franc
Alsac
Belgi
Holla
Czech
Austr
Polan
Russi
Spain
Jugos
Other
Tota
AMER
Unite
Cana
South
Other
Total
ASIA:
Japa
China
Britis
Siber
Other
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AFRI
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that the 1913 output has only been exceeded once—namely, in 1927—and that by a very small margin, so that we can assume that the coal output of the world is practically stationary. We can also assume that the fuel and power requirements of the world are being met to a much lesser extent by coal than before. This has been due partly to the study of fuel economy, partly to the higher efficiency of power-generating and power-consuming plant, and partly to the wider use of substitutes for coal fuel, such as oil and water power.

Examination of statistics for separate continents shows that the greatest relative increase has taken place in Asia, due to developments in Japan and British India. In Europe, with the exception of 1927, there has been a heavy decline from the pre-war total, in spite of the fact that Germany has more than recovered her pre-war position. The decline has been due to a fall in British production, followed by a fall in Russia and Upper Silesia. France, Belgium, and Holland have shown a decided upward movement, the Dutch figure being specially noteworthy in this connection. Russia has now exceeded her pre-war level. In America, the statistics for the United States have shown a tendency to move forward, very slightly, however, while Canada, owing to the enormous increase in water power development, has registered a slight decline. Among other countries, the Union of South Africa has shown the greatest relative improvement.

Examination of world production makes clear, above all, the fact that no excessive strain will be laid on existing sources by any rapid increase, either in production or consumption. The tendency is towards decline, and this tendency, if it does become accentuated, must render less urgent the effective utilisation of coal resources.

In brown coal, which only accounts for a very small percentage of the world's fuel consumption, progress have been fairly rapid since 1913, the output in 1927 being 53 per cent. above that of 1913. The countries responsible for this development were, above all, Germany with an increase of 73 per cent., Canada with an increase of 1,696 per cent., Bulgaria with an increase of 229 per cent., and France with an increase of 33 per cent.; the only three countries showing a serious decline being Czecho-Slovakia, Poland, and Russia. Germany is now responsible for almost 80 per cent. of the world's production, so that, if we except that country, we can consider developments in this sphere as of practically no significance.

In coke production, although there has been a steady upward movement since 1921, when the output was only 69.5 per cent. of the pre-war total, it was only in 1927 that the pre-war average was exceeded, the net increase being 5.5 per cent. The three countries showing the greatest relative improvement are Belgium, Poland, and Spain. Germany has not yet reached the pre-war average, France has barely exceeded it, while Great Britain is probably now producing on a 1913 level. The greatest decrease of all has been registered by the Saar, followed by Russia and Czecho-Slovakia.

The significance of coke production from a power point of view lies in the fact that coke is used almost entirely for heating purposes, and the coal which goes towards its production should be subtracted from the total coal output of the world used for power purposes. Thus the coke statistics given bear almost entirely on metallurgical and foundry coke and not on gasworks, so that the statistics given here are not complete. Even so, at least 150,000,000 tons of coal out of a total annual world production of 1,200,000,000 tons are devoted to coke production.

The by-products derived from coal distillation form in themselves power resources of some considerable importance. Thus, we find from the German statistics that one ton of coke supplies 100 cubic metres of gas for illuminating, power, heating, and metallurgical purposes, so that the world output on this basis would account for 11,300,000,000 cubic metres of gas, equivalent to 400,000,000,000 cubic feet. Similarly, other by-products include benzoles, fuel oils, motor oils, and light oils of various kinds, all of them capable of producing power. Any calculation made, therefore, of the power production of the world would require to make allowance for these by-products. In view, however, of the fact that no reliable statistics have been compiled of by-product recovery from the distillation of coal for more than the principal industrial countries, it is difficult to make an estimate which could be regarded as reliable.

In addition to this by-product gas, one must consider the output of natural gas, principally from the oil wells. The only statistics available, covering seven countries, show that the world's output of natural gas is about 1,360,000,000,000 cubic feet, which is almost four times the volume of gas available from the distillation of coal used in the manufacture of coke.

TABLE XVII

PRODUCTION OF NATURAL GAS

(000 cu. ft.)

Country	1924	1925	1926
U.S.A.	1,141,521,000	1,188,571,000	1,313,019,000
Canada	14,881,336	16,902,897	18,431,252
Poland	15,465,869	18,893,736	Not available
Roumania	12,795,223	13,060,119	13,304,994
Jugo-Slavia	3,000,000*	3,000,000*	3,000,000*
Japan	885,000	819,497	802,000
Italy	236,609	244,866	209,770

*Approximate.

The oil resources of the world, as estimated by the U.S. Geological Survey, are given in the following table in millions of barrels, the ratio of barrels to tons being 7 in 1, *i.e.*, seven barrels in one ton.

TABLE XVIII

OIL RESOURCES OF THE WORLD

Country	Millions of Barrels	Per cent. of World Production	Relation between U.S. resources and resources of other countries
U.S.A.	7,000	16·26	100·00
Canada	995	2·31	14·21
Mexico	4,525	10·51	64·64
Northern South America (including Peru)	5,730	13·31	81·86
Southern South America (including Bolivia)	3,550	8·25	50·71
Algeria and Egypt	925	2·15	13·21
Persia and Mesopotamia ...	5,821	13·52	83·14
S.E. Russia, S.W. Siberia and the Caucasus	5,830	13·54	83·29
Northern Russia and Sachalin	925	2·15	13·21
Roumania, Galicia and Western Europe	1,135	2·64	16·21
Japan and Formosa	1,235	2·87	17·64
China	1,375	3·19	19·64
India	995	2·31	14·21
East Indies	3,015	7·00	43·07
World	43,055	100·00	—

The third column of the table shows the relation between the output of the United States and the output of the principal countries of the world. The United States has still the highest volume of oil resources in the world, but it is followed closely by Southern

TABLE XIX

ESTIMATED WORLD PRODUCTION OF OIL
(000 Metric Tons)

Country	1919	1920	1921	1922	1923	1924	1925	1926	1927
Canada ...	31·92	26·08	25·17	23·71	22·77	23·33	21·34	48·27	63·51
India ...	1,156·95	993·38	909·14	1,026·49	1,003·31	1,086·67	1,000·00	1,059·60	1,086·09
Sarawak ...	—	—	186·89	390·73	514·83	600·00	595·00	569·54	662·25
Trinidad ...	243·85	275·90	311·81	323·81	404·09	537·30	580·99	658·47	712·61
France ...	45·56	51·48	51·92	60·00	66·62	58·13	63·65	75·03	82·58
Germany ...	30·99	28·09	26·49	34·97	46·89	46·67	54·67	79·47	92·72
Czecho-Slovakia ...	—	—	—	15·89	13·25	13·33	9·00	6·62	18·54
Italy ...	4·64	4·53	4·64	4·83	4·24	4·40	4·50	5·96	7·95
Poland ...	801·85	742·53	705·60	732·43	737·18	770·79	811·91	796·09	722·60
U.S.A. ...	50,029·01	59,120·26	62,618·53	73,006·23	97,864·53	95,461·09	100,641·93	102,723·35	119,715·32
Mexico ...	11,532·85	21,661·59	25,836·29	24,527·15	19,939·79	18,613·00	15,310·29	11,930·11	8,492·87
Colombia ...	—	—	—	42·38	56·42	66·67	134·27	853·78	1,933·78
Peru ...	346·49	373·07	472·52	715·23	844·37	1,053·33	1,221·90	1,456·95	1,298·01
Venezuela ...	56·29	60·53	142·78	288·74	503·31	1,200·87	2,790·00	4,930·60	8,529·80
Argentina ...	156·69	220·66	231·39	357·62	430·46	512·53	780·00	602·65	1,152·32
Russia ...	3,377·22	3,368·16	3,774·83	3,973·51	5,055·23	6,021·60	6,933·34	8,211·92	9,589·40
Roumania ...	876·03	984·81	1,105·56	1,365·77	1,509·80	1,851·23	2,313·42	3,241·33	3,661·36
Persia ...	849·27	1,636·11	1,933·78	2,960·27	3,311·26	4,246·00	4,622·00	4,688·74	4,874·17
Dutch East Indies ...	2,043·44	2,321·75	2,384·11	2,315·23	1,986·76	2,800·00	2,267·00	2,874·17	2,834·44
Japan and Formosa ...	288·08	283·41	344·37	257·62	224·50	213·33	266·00	241·06	225·17
Other Countries ...	100·25	135·47	133·24	13·84	27·81	19·14	17·27	8·24	26·49
TOTAL ...	72,170·19	92,425·82	101,355·47	112,594·72	134,704·78	135,347·02	140,610·33	145,227·52	165,950·18

Russia, South-Western Siberia, and the Caucasus, by Persia and Mesopotamia, and by the Northern States of South America, including Peru. Other countries which enter into consideration are Mexico, the Dutch East Indies, China, Japan, and India. These estimates, of course, represent very largely an intelligent guess, and suffer from the defects already indicated by Dr. Gustav Egloff. They can only be regarded as extremely provisional.

The world production of oil since 1919 is shown in the following table, the source of information being the "Petroleum Year Book, 1928." Production has increased 130 per cent. in eight years, the United States being responsible for the greater part of this increase. The American output has risen from 50,000,000 metric tons in 1919 to 120,000,000 tons in 1927—an increase of 138 per cent.—the American proportion of the world total being now 72.5 per cent. In Mexico, there has been a steady decline since 1921, Indian production has remained stationary, and the rate of expansion in the Dutch East Indies has shown a tendency to decline since 1924. In Japan and Formosa and in Poland the output has been stationary during the whole of eight years, and in both countries there is a tendency to decline. The countries in which the greatest progress has taken place are Colombia, Argentina, Venezuela, Peru, Persia, Russia, and Roumania, followed at a considerable distance by Trinidad. The American Continent, both North and South, with the exception of Mexico, is being developed as a whole much more rapidly than the rest of the world.

It is unnecessary to make any comparison between annual output and resources, with a view to establishing the rate of exhaustion. If this were done, the inevitable assumption would be that the United States would have only seven years or so before complete exhaustion will take place. It is hardly possible to place any credence in such a calculation, and a more reliable assumption would be that the estimate made of the oil resources of the world is subject to radical modification, as the technique of mining and of oil extraction changes and the distillation of the crude into more refined products becomes adapted to economic conditions and more complete technical knowledge.

SECTION III

WATER POWER

SECTION III

WATER POWER

ESTIMATE OF J. W. MEARES—METHODS OF CALCULATION—U.S. GEOLOGICAL SURVEY—COMPARISON WITH WORLD POWER CONFERENCE STATISTICS—WATER POWER RESOURCES, DEVELOPED AND UTILISED, OF UNITED STATES, CANADA, JAPAN—JAPANESE OFFICIAL ESTIMATE VERSUS U.S. GEOLOGICAL SURVEY ESTIMATE—GERMANY—CONFLICTING NATURE OF FRENCH ESTIMATES—SWITZERLAND—NORWAY—POLAND — ROUMANIA — CZECHO-SLOVAKIA — HUNGARY — DUTCH EAST INDIES.

At the World Power Conference of 1924 a number of countries submitted estimates of their total fuel resources, and a summary of all these papers was made by Mr. J. W. Meares in *World Power*, January 1925. In this paper Mr. Meares adopted certain factors for converting the power developed into kilowatts as measured by the output at the busbars of the generating stations. He adopted the system which has been common to American and Canadian estimates of ordinary minimum flow—namely, 90 per cent. of all the year—but distinguished between turbine horse-power and electric horse-power. Thus he converted electric horse-power direct to kilowatts by multiplying by .746, 1 kW. being equal to 1.34 H.P., and turbine horse-power to kilowatts of output by multiplying by $.9 \times .746$, allowing in this case for the efficiency of the generator, which is taken as 90 per cent. A third calculation, where only a theoretical horse-power was given, led to the introduction of a new limiting factor to cover the total efficiency of the generating plant, and in this case he arrived at a final figure which is 54 per cent. of the first. The main intention of the author was, of course, to obtain some standard method of comparison, and he chose kilowatts of actual output. The result of all these calculations was that the total water power resources of the world amounted to 138,000,000 kilowatts.

The *U.S. Geological Survey* issues annually a statement of the water power resources of the world, developed and available.

TABLE XX

WATER POWER RESOURCES OF THE WORLD

(January, 1927)

Country	Population	Area Km²	H.P. Utilised	H.P. Potential	H.P. Utilised per Head of Population	H.P. Potential per Km²
EUROPE:						
Sweden	6,053,562	448,460	1,350,000	3,000,000	0·223	6·69
Norway	2,649,775	323,795	1,900,000	9,500,000	0·717	29·41
Finland	3,435,249	387,565	220,000	1,800,000	0·064	4·65
Russia	132,984,413	22,792,074	230,000	3,000,000	0·00172	0·131
Esthonia	1,109,479	47,550	16,950	125,000	0·0144	2·64
Latvia, Lithuania	3,944,397	119,034	5,000	100,000	0·00126	0·84
Poland	27,185,709	388,279	90,000	1,400,000	0·00331	3·60
Ukraine	28,406,700	447,300	40,000	425,000	0·0014	0·95
Caucasus	13,948,000	537,000	5,000	5,000,000	0·000358	9·34
Hungary	7,984,558	92,951	3,000	175,000	0·000375	1·89
Czecho-Slovakia	13,611,349	140,352	155,000	1,000,000	0·0113	7·10
Jugoslavia	12,017,323	248,987	180,000	3,000,000	0·0149	12·2
Austria	6,562,661	83,904	325,000	1,660,000	0·0495	19·8
Roumania	17,500,000	294,967	30,000	1,600,000	0·00171	5·47
Bulgaria	4,866,971	103,146	18,000	1,200,000	0·00369	11·6
Greece	5,810,221	127,337	8,000	250,000	0·00137	1·96
Italy	38,710,576	310,226	2,300,000	3,800,000	0·0594	12·25
Albania	817,468	30,000	1,000	500,000	0·0122	16·66
Switzerland	3,880,320	41,295	1,850,000	2,500,000	0·476	60·97
Germany	62,500,000	472,034	1,100 000	2,000,000	0·0176	4·23
France	39,595,612	550,986	2,000,000	5,400,000	0·0505	9·81
Gt. Britain and Ireland	47,286,444	312,914	250,000	850,000	0·0052	2·72
Belgium	7,684,474	30,437	700	—	0·0910	—
Denmark	3,419,656	44,415	11,000	9,000	0·0032	0·20
Holland	7,416,419	34,208	150	—	0·0202	—
Spain	21,339,477	505,177	1,000,000	4,000,000	0·0468	7·92
Portugal	6,032,991	91,948	10,000	300,000	0·0016	3·29
TOTAL	526,753,804	29,013,341	13,248,650	52,594,000	0·0251	1·81
NORTH AMERICA						
Mexico	14,334,780	1,969,149	300,000	6,000,000	0·0209	3·04
United States	105,710,620	7,839,959	11,721,000	35,000,000	0·110	4·46
Alaska	55,000	1,518,700	43,000	1,000,000	0·781	0·65
Canada	9,360,000	9,572,600	4,556,000	18,250,000	0·486	1·90
Newfoundland	260,000	110,670	160,000	400,000	0·615	3·63
Costa Rica	498,435	48,550	15,000	1,000 000	0·0301	20·83
Guatemala	2,004,900	109,724	4,000	1,300,000	0·0019	11·92
Honduras	760,465	100,048	3,000	1,000,000	0·0394	10·00
Nicaragua	638,119	118,453	400	800,000	0·00626	6·77
Salvador	1,610,000	20,951	2,700	200,000	0·00172	10·00
Panama	445,400	74,522	13,300	500,000	0·0298	6·75
West Indies	9,190,700	214,844	19,350	150,000	0·0026	0·70
TOTAL	144,868,419	21,698,170	16,837,750	65,600,000	0·116	3·02
SOUTH AMERICA						
Argentina	10,087,118	2,978,590	25,000	5,000,000	0·00247	1·67
Bolivia	2,889,970	1,590,000	13,500	2,500,000	0·00449	1·58
Brazil	37,300,000	8,522,000	500,000	26,000,000	0·0134	13·05
British Guiana	314,000	231,800	—	2,500,000	—	0·82
Dutch Guiana	116,200	129,100	—	800,000	—	6·20
French Guiana	49,000	88,200	—	500,000	—	5·69
Colombia	6,617,838	1,283,864	25,000	4,000,000	0·00375	3·11
Chili	3,992,854	751,515	114,000	2,500,000	0·0285	3·32
Ecuador	2,000,000	443,750	5,500	1,000,000	0·00275	2·25
Paraguay	800,000	253,100	200	2,000,000	0·00025	7·90
Peru	5,500,000	1,355,054	55,000	4,500,000	0·0100	3·32
Uruguay	1,640,214	186,926	—	300,000	—	1·65
Venezuela	2,411,952	1,020,400	13,000	3,000,000	0·00539	2·95
TOTAL	73,619,146	18,834,299	751,200	54,600,000	0·0101	2·89

TABLE XX (*Continued*)

WATER POWER RESOURCES OF THE WORLD

(January, 1927)

Country	Population	Area Km²	H.P. Utilised	H.P. Potential	H.P. Utilised per Head of Population	H.P. Potential per Km²
AFRICA:						
Tangier	70,000	400	—	50,000	—	125·00
Morocco	5,843,414	448,213	—	250,000	—	0·558
Algeria	6,806,090	575,511	130	200,000	0·000019	0·347
Tunisia	2,159,708	125,130	—	30,000	—	0·247
Gold Coast and British Togoland	2,106,000	203,600	—	1,450,000	—	7·12
Liberia	1,900,000	95,400	—	4,000,000	—	42·10
Sierra Leone ..	1,535,000	80,300	—	1,700,000	—	21·25
Senegal	12,300,000	4,800,000	—	230,000	—	0·0479
Union of S. Africa	7,291,000	1,223,000	5,000	1,600,000	0·00068	1·30
Angola	4,200,000	1,255,700	4,000	4,000,000	0·000952	3·18
South-West Africa	230,000	808,000	—	150,000	—	0·185
Belgian Congo and Belgian Mandate	11,000,000	2,889,000	250	90,000,000	0·0000227	32·26
French Congo ..	582,000	240,000	—	35,000,000	—	14·58
French Cameroons	3,000,000	431,000	—	13,000,000	—	30·16
Nigeria & British Cameroons ..	18,000,000	970,600	—	9,000,000	—	9·27
Rhodesia	2,110,000	1,140,600	2,500	2,500,000	0·00118	2·19
Tanganyika ..	4,160,000	950,000	800	2,700,000	0·000192	2·84
British Cen. Africa	7,287,000	1,119,580	—	1,200,000	—	1·00
Portuguese East Africa	3,150,000	761,100	—	3,700,000	—	1·78
British East Africa	220,000	2,640	900	4,700,000	0·00409	2350·00
Bechuanaland ..	152,000	729,000	—	200,000	—	0·0274
Abyssinia	10,000,000	1,120,400	—	4,000,000	—	3·57
Egypt	14,168,756	994,380	—	600,000	—	0·603
Ivory Coast, Dahomey and French Togoland	2,387,000	422,000	—	2,850,000	—	6·75
French Guinea ..	1,875,000	242,000	—	2,000,000	—	8·26
French Sudan ..	2,474,000	1,672,000	—	1,000,000	—	0·598
Madagascar ..	3,387,968	627,327	420	4,070,000	0·000123	6·49
TOTAL	128,394,936	23,926,281	14,000	185,930,000	0·000106	7·77
ASIA:						
China	330,000,000	11,306,000	1,650	20,000,000	0·000005	1·76
India	319,646,580	4,901,922	210,000	27,000,000	0·000656	5·50
Turkish Asia Minor	13,180,000	923,000	500	500,000	0·0379	0·54
Persia	9,000,000	1,645,000	—	200,000	—	0·121
Afghanistan ..	10,000,000	731,000	2,000	500,000	0·00020	0·683
Siberia	9,307,002	10,783,049	90,800	8,000,000	0·00967	0·741
French India ..	19,576,000	700,842	—	4,000,000	—	5·71
Siam & Malay States	12,170,000	650,214	4,500	4,000,000	0·000369	6·15
Japan	59,736,704	381,250	1,750,000	4,500,000	0·0292	11·81
Corea	19,519,927	220,741	18,300	500,000	0·000937	2·27
TOTAL	802,136,213	32,243,018	1,869,850	69,200,000	0·00233	2·14
AUSTRALASIA:						
Australia	6,049,000	7,938,800	2,000	600,000	0·00033	0·0755
New Zealand ..	1,338,654	2,268,264	60,000	2,500,000	0·0448	1·10
Philippines ..	10,800,000	297,905	—	1,500,000	—	5·05
Sumatra & Celebes	300,000	401,500	20,500	3,000,000	0·0666	7·48
Java	35,010,000	131,508	60,000	750,000	0·00171	5·72
Borneo, New Guinea & Papua..	1,425,000	440,000	—	7,500,000	—	17·00
Tasmania	209,000	67,900	75,000	700,000	0·358	10·44
Hawaii	260,000	6,702	25,000	100,000	0·0961	14·92
TOTAL	55,391,654	11,552,579	242,500	16,650,000	0·00436	1·44

TABLE XX (*Continued*)

WATER POWER RESOURCES OF THE WORLD

(January, 1927)

Continent	Population	Area Km²	H.P. Utilised	H.P. Potential	H.P. Utilised per Head of Population	H.P. Potential per Km²
Europe	526,753,804	29,013,341	13,248,650	52,594,000	0·0251	1·81
North America ..	144,868,419	21,698,170	16,837,750	65,600,000	0·116	3·02
South America ..	73,719,146	18,834,299	751,200	54,600,000	0·0101	2·89
Asia	802,136,213	32,243,018	1,860,850	69,200,000	0·00233	2·14
Africa	128,394,936	23,926,281	14,000	185,930,000	0·000109	7·77
Australasia ..	55,391,654	11,552,579	242,500	16,650,000	0·00436	1·44
GRAND TOTAL ..	1,731,264,172	137,267,688	32,963,950	444,574,000	0·0190	3·23

These estimates are probably based, as far as possible, on a 90 per cent. continuous flow during the year and, as far as one can judge, on turbine horse-power. They are standardised, therefore, not in kilowatts of output, but in horse-power of turbine plant capacity, so that their figure must be multiplied by ·67 to obtain a figure comparable with that given by Mr. J. W. Meares.

The *U.S. Geological Survey*, in a statistical compiliation dated January, 1927, gives the total potential horse-power as 445,000,000 H.P. Applying Mr. Meares' calculations, we obtain 298,000,000 kW. of electric output, which is more than twice that given by Mr. Meares. Even if we assume that these potential water power resources are purely theoretical water horse-power and apply the 54 per cent. ratio already established, we obtain a resultant figure of 240,000,000 kW., which is still very much higher than that given by Mr. Meares working on the papers read at the 1924 World Power Conference.

A detailed comparison between the two returns shows considerable differences. Russia, for example, is shown in the 1924 World Power Conference as having 824,000 H.P. developed, while the *U.S. Geological Survey* gives 230,000 H.P.; Sweden, according to the 1924 Conference, had 1,416,000 H.P. developed in 1924, compared with 1,350,000 H.P. as given in the *U.S. Geological Survey*. With the exception of a small number of countries, there is practically no relation between the two sets of figures. It is difficult, therefore, to say which compilation comes closer to the truth, and the only check—and it is highly unsatisfactory—is to take some of the countries about which we have information of a reliable nature, and strive, with reference to it, to modify or perhaps confirm the statistics given by the *U.S. Geological Survey*.

TABLE XXI

POTENTIAL WATER-POWER RESOURCES OF THE UNITED STATES

(U.S. Geological Survey)

State and Division	Available 90% of the time		Available 50% of the time	
	H.P.	%	H.P.	%
UNITED STATES ...	38,110,000	100·00	59,166,000	100·00
New England	998,000	2·62	1,978,000	3·34
Middle Atlantic	4,373,000	11·47	6,050,000	10·23
East North Central ...	742,000	1·95	1,426,000	2·41
West North Central ...	929,000	2·44	1,937,000	3·27
South Atlantic	2,924,000	7·67	5,048,000	8·53
East South Central ...	1,328,000	3·48	2,272,000	3·84
West South Central ...	559,000	1·47	1,110,000	1·88
Mountain	10,844,000	28·46	15,552,000	26·29
Pacific	15,413,000	40·44	23,793,000	40·21
NEW ENGLAND:				
Maine	536,000	1·41	1,074,000	1·81
New Hampshire	186,000	·49	350,000	·59
Vermont	80,000	·21	169,000	·28
Massachusetts	106,000	·28	235,000	·40
Rhode Island	25,000	·06	40,000	·07
Connecticut	65,000	·17	110,000	·19
MIDDLE ATLANTIC:				
New York	4,010,000	10·52	4,960,000	8·39
New Jersey	50,000	·13	90,000	·15
Pennsylvania	313,000	·82	1,000,000	1·69
EAST NORTH CENTRAL:				
Ohio	55,000	·14	166,000	·28
Indiana	45,000	·12	145,000	·25
Illinois	189,000	·50	361,000	·61
Michigan	168,000	·44	274,000	·46
Wisconsin	285,000	·75	480,000	·81
WEST NORTH CENTRAL:				
Minnesota	203,000	·53	401·000	·68
Iowa	169,000	·44	395,000	·67
Missouri	67,000	·18	152,000	·26
North Dakota	82,000	·22	193,000	·32
South Dakota	121,000	·32	203,000	·34
Nebraska	183,000	·48	342,000	·58
Kansas	104,000	·27	251,000	·42
SOUTH ATLANTIC:				
Delaware	5,000	·01	10,000	·02
Maryland and District of Columbia	106,000	·28	238,000	·40
Virginia	459,000	1·20	812,000	1·37
West Virginia	355,000	·93	980,000	1·66
North Carolina	852,000	2·24	1,160,000	1·96
South Carolina	555,000	1·46	860,000	1·45
Georgia	572,000	1·50	958,000	1·62
Florida	20,000	·05	30,000	·05

TABLE XXI (*Continued*)

POTENTIAL WATER-POWER RESOURCES OF THE UNITED STATES

(U.S. Geological Survey)

State and Division	Available 90% of the time		Available 50% of the time	
	H.P.	%	H.P.	%
EAST SOUTH CENTRAL:				
Kentucky	172,000	·45	280,000	·47
Tennessee	654,000	1·71	882,000	1·50
Alabama	472,000	1·24	1,050,000	1·77
Mississippi	30,000	·08	60,000	·10
WEST SOUTH CENTRAL:				
Arkansas	200,000	·52	300,000	·51
Louisiana	1,000	·01	2,000	·01
Oklahoma	70,000	·18	194,000	·33
Texas	288,000	·76	614,000	1·03
MOUNTAIN:				
Montana	2,550,000	6·69	3,700,000	6·25
Idaho	2,122,000	5·57	4,032,000	6·81
Wyoming	704,000	1·85	1,182,000	2·00
Colorado	873,000	2·29	1,609,000	2·72
New Mexico	116,000	·30	186,000	·32
Arizona	2,759,000	7·24	2,887,000	4·88
Utah	1,420,000	3·73	1,586,000	2·68
Nevada	300,000	·79	370,000	·63
PACIFIC:				
Washington	7,145,000	18·71	11,225,000	18·97
Oregon	3,665,000	9·61	5,594,000	9·96
California	4,603,000	12·09	6,674,000	11·28
OUTLYING POSSESSIONS:				
Alaska	1,000,000	—	2,500,000	—
Porto Rico	19,000	—	28,000	—
Hawaii	100,000	—	200,000	—

NOTE.—"The figures given in the estimate show the 24-hour horse-power available 90 per cent. of the time and 50 per cent. of the time, at an overal efficiency of 70 per cent. at all developed and undeveloped sites. Where reservoirs are already built or where detailed examinations show that storage in reservoirs is feasible, the estimate includes the power that could be obtained from water thus stored. The inclusion of power available from storage sites increases considerably the figures for power available 90 per cent. of the time, but has little effect on the figures for power available 50 per cent. of the time The estimate includes half of the potential power of Niagara River and of the international section of St. Lawrence River, though an international agreement is necessary to permit the full use of these resources.

"This estimate, though the most accurate yet made, cannot be considered final. Surveys and detailed studies are necessary to determine the most economical method of development, and these studies will lead to changes in the estimates of potential power in individual states. Additional data are especially desirable for some of the Southern and Central States.

"These figures for potential power are not directly comparable with the figures for developed power, because developed power is usually given in terms of the capacity of the installed water-wheels or turbines, which may be several times the potential power available 90 per cent. of the time. Probably with complete development of the water-power resources of the whole country the installed capacity would amount to 80,000,000 H.P. or more."—(*U.S. Geological Survey Report.*)

We shall deal with America first, as being the most important water power centre. The latest available statistics, dated 1928, and supplied by the *U.S. Geological Survey,* give a total capacity of water power plant above 100 H.P. as 12,296,000 H.P., and the total available power resources, on a 90 per cent. basis, as 38,110,000 H.P. A distinction is made, in this case, between resources available 90 per cent. of the time and 50 per cent. of the time. The relevant statistics, step by step, are given in Table XXII. The Canadian statistics, as supplied by the Dominion Water Power and Reclamation Service in January, 1928, gave the total water power resources as 20,197,000 H.P., and the total turbine plant capacity as 4,777,921 H.P. These two important figures do not correspond entirely with those of *U.S. Geological Survey,* and are slightly higher. With reference to other American territories, no reliable information has been available.

Japan is a particularly glaring example of fluctuating estimates. According to the Japanese Ministry of Communications, the total water power resources available during the year amounted to 6,415,000 H.P., which are capable of expansion to 11,933,000 H.P. using every potentiality, with a maximum figure of 14,090,000 H.P. available probably for about 50 per cent. of the time. This compares with the figure given by the *U.S. Geological Survey* of 4,500,000 H.P., available on a 90 per cent. basis. Again, by the end of 1926, concessions had been granted for a total of 8,323,396 H.P., 3,586,795 H.P. of which were actually under construction or installed, with the remainder projected. All these figures are several times those given by the *U.S. Geological Survey,* and may be regarded as more accurate. At the end of 1926, the total capacity of water power plants installed and in operation was 2,640,000 H.P.

In Europe, the latest German figures, as given in the following table,* are so different from those given by the *U.S. Geological Survey* that the latter's compilation cannot be regarded as at all satisfactory. We know from the German Census of 1925 that the total capacity of water power plant installed in Germany is very considerably in excess of that given by the *U.S. Geological Survey.*

In France, several estimates have been made of water power resources, none of which can be regarded as final. For example, the

*Source: Aufbau und Entwicklungsmöglichkeiten der europäischen Elektrizitätswirtschaft (Schwarz, Goldschmidt & Co., Berlin) pp. 47 and 54.

TABLE XXII

DEVELOPED WATER POWER IN THE UNITED STATES

JANUARY 1, 1928

(Plants of 100 H.P. or more as reported by the U.S. Geological Survey)

Division and State	Total		Public Utility and Municipal		Manufacturing and Miscellaneous	
	Number of Plants	Capacity in H.P.	Number of Plants	Capacity in H.P.	Number of Plants	Capacity in H.P.
UNITED STATES	3,397	12,296,000	1,600	10,538,381	1,797	1,757,619
New England ..	1,198	1,556,062	259	778,243	939	777,711
Middle Atlantic ..	613	2,077,820	247	1,811,483	366	266,337
East North Central	382	1,036,785	263	807,440	119	229,345
West North Central	205	541,627	155	445,190	50	96,437
South Atlantic ..	349	1,967,250	170	1,726,512	179	240,738
East South Central	58	966,103	44	963,281	14	2,822
West South Central	33	44,432	22	40,927	11	3,505
Mountain	245	1,117,668	194	1,095,530	51	22,138
Pacific	314	2,988,261	246	2,869,675	68	118,586
NEW ENGLAND:						
Maine	250	537,161	78	234,230	172	302,931
New Hampshire ..	244	278,002	62	143,711	182	134,291
Vermont	196	200,157	66	156,501	130	43,656
Massachusetts ..	325	362,123	28	159,211	297	202,912
Rhode Island ..	59	30,188	5	3,285	54	26,903
Connecticut ..	124	148,423	20	81,405	104	67,018
MIDDLE ATLANTIC:						
New York	529	1,779,322	194	1,528,170	335	251,152
New Jersey ..	34	18,902	10	8,658	24	10,244
Pennsylvania ..	50	279,596	43	274,655	7	4,941
EAST NORTH CENTRAL:						
Ohio	24	30,320	16	25,236	8	5,084
Indiana	26	56,521	17	50,620	9	5,901
Illinois	31	94,202	16	77,277	15	16,925
Michigan	134	378,267	113	327,685	21	50,582
Wisconsin	167	477,475	101	326,622	66	150,853
WEST NORTH CENTRAL:						
Minnesota	70	276,494	48	198,176	22	78,318
Iowa	51	183,908	42	182,207	9	1,701
Missouri	7	20,560	5	20,260	2	300
North Dakota ..	1	245	0	0	1	245
South Dakota ..	9	19,671	5	7,050	4	12,621
Nebraska	44	23,825	40	23,140	4	695
Kansas	23	16,914	15	14,357	8	2,557
SOUTH ATLANTIC:						
Delaware	3	1,161	0	0	3	1,161
Maryland	15	37,815	4	33,765	11	4,050
District of Colombia	3	5,870	1	4,520	2	1,350
Virginia	65	141,471	35	99,857	30	41,614
West Virginia ..	12	91,279	7	81,174	5	10,105
North Carolina ..	125	643,768	50	511,706	75	132,062
South Carolina ..	60	574,478	33	546,371	27	28,107
Georgia	63	463,453	37	441,164	26	22,289
Florida	3	7,955	3	7,955	0	0
EAST SOUTH CENTRAL						
Kentucky	7	142,255	4	141,351	3	904
Tennessee	31	177,425	24	176,170	7	1,255
Alabama	20	646,423	16	645,760	4	663
Mississippi	0	0	0	0	0	0
WEST SOUTH CENTRAL						
Arkansas	4	15,550	4	15,550	0	0
Louisiana	0	0	0	0	0	0
Oklahoma	4	1,948	4	1,948	0	0
Texas	25	26,934	14	23,429	11	3,505
MOUNTAIN:						
Montana	31	377,540	29	375,600	2	1,940
Idaho	53	355,277	46	352,275	7	3,002
Wyoming	11	17,280	10	16,954	1	326
Colorado	58	94,816	29	81,231	29	13,585
New Mexico ..	6	1,510	5	1,285	1	225
Arizona	10	104,360	10	104,360	0	0
Utah	67	153,435	57	150,675	10	2,760
Nevada	9	13,450	8	13,150	1	300
PACIFIC:						
Washington ..	74	706,622	68	663,490	6	43,132
Oregon	84	288,859	49	232,487	35	56,372
California	156	1,992,780	129	1,973,698	27	19,082

TABLE XXIII

DISTRIBUTION OF THE DEVELOPED WATER POWER IN CANADA

(November 1, 1927)

Province	Turbine Installation in horse-power				Population June 1, 1927	Total Installation per 1,000 Population	Available 24-hour power at 80 per cent. efficiency		
	In Central Electric Stations	In Pulp and Paper Mills	In other Industries	Total			At Ordinary Minimum Flow, H.P.	At Ordinary Six Months Flow, H.P.	Turbine Installation H.P.
1	2	3	4	5	6	7	8	9	10
						H.P.			
British Colombia ...	330,679	80,500	61,883	473,062	575,000	822·0	1,931,000	5,103,500	473,062
Alberta	33,520	—	587	34,107	617,000	55·0	390,000	1,049,500	34,107
Saskatchewan	—	—	35	35	836,000	0·04	542,000	1,082,000	35
Manitoba	238,725	—	16,400	255,125	647,000	394·0	3,309,000	5,334,500	255,125
Ontario	1,544,766	174,548	107,774	1,827,088	3,187,000	573·0	5,330,000	6,940,000	1,827,088
Quebec	1,796,692	242,044	126,707	2,165,443	2,604,000	832·0	8,459,000	13,064,000	2,165,443
New Brunswick ...	25,825	13,003	8,403	47,231	411,000	115·0	87,000	120,800	47,231
Nova Scotia	31,942	16,636	17,124	65,702	543,000	121·0	20,800	128,300	65,702
Prince Edward Island ...	279	—	1,995	2,274	87,000	26·0	3,000	5,300	2,274
Yukon and North West Territory	10,000	—	3,199	13,199	12,000	1,100·0	125,200	275,300	13,199
Canada	4,012,428	526,731	344,107	4,883,266	9,519,000	513·0	20,197,000	33,113,200	4,883,266

Column 2 includes only hydro-electric stations which develop power for sale.

Column 3 includes only water-power *actually developed* by pulp and paper companies. In addition to this total, pulp and paper companies purchase from the hydro-power central stations totalled in Column 2 horse-power estimated at about 831,000, making a total of about 1,358,000 H.P. actually used in the manufacture of pulp and paper.

Column 4 includes only water power *actually developed* in connection with industries other than the central station and pulp and paper industries. These industries also purchase blocks of power from the central stations which are totalled in Column 2.

Column 5 totals all turbines and water wheels installed in Canada.

Column 6 lists the population as of June 1, 1927, according to estimates made by the Dominion Bureau of Statistics.

Column 7 averages the developed water power per 1,000 population.

[*To face p.* 46.

TABLE XXIV

WATER POWER RESOURCES OF GERMANY

Region	Available		Total Potential Annual Output in Millions Units	Developed and under Construction		Total Possible Annual Output in Millions Units
	H.P.	kW.		H.P.	kW.	
Bayern	3,000,000	2,200,000	12,000	804,100	591,000	2,955
Prussia and the rest of Germany ..	2,530,000	1,865,000	9,325	500,000	368,000	1,840
Baden	1,018,000	750,000	3,750	200,000	147,200	736
Württemberg ..	252,000	185,000	925	95,000	70,000	350
Total	6,800,000	5,000,000	26,000	1,599,100	1,176,200	5,881

TABLE XXV

TOTAL POWER RESOURCES OF GERMANY

Unit of Weight	Coal		Peat	Wood	Oil-Shales	Water-Power	Oil	Total
	Hard Coal	Brown Coal						
Millions of tons without conversion into hard coal values ..	90,340	21,900	10,000	16,000	117,000	43,800 Million Units	—	—
	112,240							
Millions of tons after conversion into hard coal values ..	90,340	7,300	5,000	8,000	14,625	37,000	—	162,265
	97,640							
Percentage of Total ..	55·5%	4·5%	3·1%	4·9%	9%	23%	—	100%
	60							

Commission des Forces Hydrauliques, created in 1919 by the Superior Council of Public Works, give the total water power available in France as 9,000,000 H.P., 2,200,000 H.P. of which is represented by the four rivers, the Rhone, the Rhine, the Loire, and the Garonne. The following table shows the position:—

TABLE XXVI

	Minimum Potential Water Power H.P.
REGIONS:	
South East	4,000,000
South West	1,500,000
Central	1,100,000
East	200,000
Total	6,800,000
RIVERS:	
Rhone	900,000
Rhine	800,000
Loire	300,000
Garonne	200,000
General Total	9,000,000

A further calculation, made by the *Chambre Syndicale des Forces Hydrauliques,* gives the total water power resources on a 90 per cent. basis as 4,600,000 H.P., and with a 50 per cent. basis as about 9,200,000 H.P., indicated in Table XXVII, overleaf.

TABLE XXVII

WATER POWER AVAILABLE IN FRANCE

Regions	Minimum Flow	Average Flow
	H.P.	H.P.
Northern Alps (Upper Savoy, Savoy, Iser, Hautes-Alpes)	1,000,000	2,000,000
Southern Alps (from the Drome to Maritime Alps)	1,300,000	2,600,000
Massif Central, Vosges, Jura	900,000	1,800,000
Pyrenees and remainder of Territory	1,400,000	2,800,000
Total	4,600,000	9,200,000

The French estimate, therefore, lies somewhere between 4,600,000 and 9,000,000 H.P., the *U.S. Geological Survey* fixing it at 5,400,000 H.P.

TABLE XXVIII

RÉCAPITULATION GÉNÉRALE DE LA STATISTIQUE DES USINES HYDRO-ELECTRIQUES DE PLUS DE 1,000 kW.

	Puissance installée en kW.	Puissance Normale Disponible en kW.		
		En état de marche	En construction	En projet
Region de Nord-Est ...	2,050	240	—	504,200
Region du Nord et Nord-Est	2,200	1,300	4,000	136,150
Region de Centre:				
En tenant compte des installations provisoires ...	124,650	65,440	118,970	505,780
Enne tenant pas compte des installations provisoires		63,100		506,470
Region du Sud-Ouest ...	316,840	175,520	70,870	721,200
Region du Jura:				
En tenant compte des installations provisoires ...	46,280	26,620	11,770	64,480
En ne tenant pas compte des installations provisoires		25,970		
Region du Sud-Ouest:				
En tenant compte des installations provisoires ...	771,240	414,630	75,960	2,016,830
En ne tenant pas compte des installations provisoires		396,500	64,660	2,027,330
Region de la Corse	—	—	—	184,640
Total pour la France:				
En tenant compte des installations provisoires ...	1,263,260	683,750	281,570	4,133,280
En ne tenant pas compte des installations provisoires		662,630	270,270	4,144,470
Total de la puissance normale disponible:				
En tenant compte des installations provisoires				5,098,600
En ne tenant pas compte des installations provisoires				5,077,370

According to the statistics of the *Ministere des Travaux Publiques*, the position of water power plant in 1923 was as in Table XXVIII.

In 1926, the total capacity of water power plant installed amounted to 1,719,000 H.P., equivalent to a continuous output of 772,000 kW. It may be possible to effect some reconciliation between all the statistics given regarding France, but until some standard method of assessing water power resources has been evolved, it would be inadvisable to do so.

In Switzerland, according to the latest statistics issued by the Federal Water Power Department, the water power position at the beginning of 1928 was as follows:—

TABLE XXIX

WATER POWER RESOURCES OF SWITZERLAND
(January 1, 1928)
(H.P. net)

Classification	Developed	Under Construction	Still to be Developed	Total
Total water power available on a continuous basis ...	637,000	134,850	1,728,150	2,500,000
Total water power available during 15 hours of the day allowing for storage reservoir capacity	1,020,000	220,000	2,760,000	4,000,000
Total capacity of plant installed	2,138,000	425,000	5,837,000	8,400,000

In Norway, according to 1922 Government statistics, the total water power resources available amounted to 12,330,000 H.P., which, however, according to S. Kloumann, should rather lie between 16,000,000 and 18,000,000 H.P. Of this 18,000,000 H.P., about 4,200,000 H.P., as indicated below, represents water powers which can be commercially exploited without excessive cost. At the end of December, 1925, the water power developed in Norway was slightly over 2,000,000 H.P., with an output in units of over 8,000,000,000.

TABLE XXX

NORWAY WEST COAST WATER POWERS CAPABLE OF GIVING 30,000 H.P. OR MORE

NORTHERN NORWAY

	El. Hp.
Elvegaardselven, mainly State property	126,000
Sulitjelma, private	90,000
Glaamfjord, State property of which 80,000 developed	140,000
Rossen, mainly State property	267,000
TOTAL	523,000

TABLE XXX (*Continued*)

NORWAY WEST COAST WATER POWERS CAPABLE OF GIVING 30,000 H.P. OR MORE

TRONDELAGEN AND SOUTHERN NORWAY

	El. Hp.
Tunnsjöfoss, private	120,000
Fiskumfoss, private	40,000
Forra in Stjordalen, private	48,000
Aura and Mardöla, now being developed, private	277,000
Aalfoten, owned by several municipalities	53,000
Höyanger, owned by Höyangfaldene, about 27,000 H.P. used by aluminium works	80,000
Jöstedalselven, private	60,000
Fortunelven, in three works, private...	130,000
Toin, owned by Norsk hydro, under development	100,000
Aurlandfaldene in Sogn, private	200,000
Arnefjord and Tennesvassdragene	60,000
Matre and Haugsdal	90,000
Bjölva, 24,000 H.P. developed, private	40,000
Osa in Hardanger, under development, private	95,000
Sima, Hardanger, private	45,000
Veigo, Hardanger, private	165,000
Kinservik, Hardanger, private	116,000
Tysse, 160,000 H.P. developed, private	200,000
Laatefoss, Hardanger	103,000
Mauranger	91,000
Blaafaldene, 95,000 H.P. in one station, by the fjord, private ...	120,000
Vaule	30,000
Saude in Ryfylke, about 45,000, employed mainly by electro-metallurgical works at Saude, private	130,000
Forra in Ryfylke, private	87,000
Ulla in Ryfylke, State-owned...	175,000
Bratslandsdalen, private	80,000
Bleskestadselven, private	75,000
Lyse in Ryfylke, particularly favourable storage facilities... ...	140,000
Aaen-Sire, owned by the town of Stavanger	50,000
TOTAL	3,000,000

INTERIOR WATER COURSES OF NORWAY AVAILABLE AT A MODERATE COST OF DEVELOPMENT

	El. Hp.
Ovre Sira and Ovre Kvinna, owned partly by the State, partly by municipal authorities, partly private	330,000
Toke, State-owned	270,000
Maarelven, partly State-owned, partly private	125,000
Hemsila, owned by municipality of Aker	63,000
Holsvassdraget, owned by the city of Oslo	120,000
Aabjora, private	86,000
Vinsterfaldene, owned by number of municipalities	200,000
TOTAL	1,194,000

The total water power resources of Poland, according to a publication of the Ministry of Public Works (1925), on an annual average basis, are 3,652,000 H.P., split up into three categories :—the first category, covering resources capable of ready exploitation, gives a total of 1,795,000 H.P.; the second category, comprising

locations less accessible, 434,000 H.P.; and the third category, of practically inaccessible resources, 1,314,000 H.P. The method of calculation adopted here is that of the monthly average carried through the year and is not on the same footing, therefore, as the system adopted elsewhere of a minimum of 90 per cent. flow.

In Roumania, according to statistics published by the *Banque Marmorosch Blank & Cie.*, the total water power resources of the country, including Transylvania and the old kingdom, may be given as 1,650,000 H.P. with 52,592 H.P. developed. In Czecho-Slovakia, to continue the European survey, statistics given at the World

TABLE XXXI

Stream and Location	Capacity		Production in millions of kWh.
	H.P.	kW.	
A. Power Plants in Operation:			
1. At the dam on River Labe (Elbe) above Dvůr Kralove	2,100	1,540	5·7
2. At Kromeriz on River Morava... ...	2,130	1,570	6·2
3. On River Labe at Podebrady	1,300	960	5·0
4. On River Labe at Nymburk	1,740	1,280	6·0
5. On River Orlice at Albrechtice ...	400	295	1·47
6. On Starohorsky Creek at Jelenec ...	2,300	1,690	3·0
7. On Mine Shaft No. IV at Kremnica (Slovakia)	1,000	736	5·0
B. Power Plants under Construction:			
8. On River Labe at Prelouc	2,670	1,960	7·56
9. On River Labe at Kolin	760	560	3·00
10. On River Vltava at Mirejovice ...	4,660	3,430	17·50
11. On Starohorsky Creek at Stare Hory...	1,300	955	4·40
12. On Jasenia Creek at Jasenia	3,000	2,200	11·66
Totals of A and B	23,360	17,176	76·49
C. Power Plants on which the Preliminary Work is Started:			
13. On River Uz above Uzhorod ...	1,760	1,300	7·3
14. On River Labe at Strekov	22,800	16,800	100·00
15. On River Labe at Krausoby Boudy	5,800	4,250	15·00
16. On River Vltava at Slapy	88,000	58,000	180·00
17. On River Vltava at Stechovice ...	32,700	21,700	94·00
18. On River Vltava at Vrane	19,800	13,000	60·00
19. On River Morava at Hodonin ...	3,000	2,200	11·60
20. On River Dyje at Vranov	6,000	4,400	31·20
21. On River Moravice at Kruzperk ...	1,100	810	4·40
22. On River Vah at Dolni Kockovce ...	20,000	15,000	88·50
23. On River Labe at Verdek (equalising reservoir)	—	—	—
Sums of C	200,960	137,460	592·00
Totals of A, B, C...	224,320	154,636	668·49

Power Conference fixed the total water power resources at 1,700,000 H.P. with 153,000 H.P. developed, while a publication, issued in 1926 by the Ministry of Public Works, stated the position in 1925, with reference to public supply undertakings only, to be as in Table XXXI.

In Hungary, the total water power resources, according to official statistics, have been given as less than 180,000 H.P., the figure quoted by the *U.S. Geological Survey.*

The figures given for Great Britain by the latter are based on the Report of the Water Power Resources Committee, which carried out a survey of the entire country in close detail. In view, however, of recent developments both in the civil and electrical engineering spheres, such an estimate may now be very considerably modified, while the statistics of water power utilised, namely, 250,000 H.P., may require to be extended to cover important schemes which are now coming close to fruition, such as those at Lochaber and Maentwrog.

With reference to other parts of the world, no reliable statistics are available which could act as a check on those given by the *U.S. Geological Survey.* This applies especially to British and French Dominions and to all the South American Republics, the

TABLE XXXII

A. JAVA

No.	Name of River	Name	Capacity in H.P. — Minimum — Absolute (1)	Capacity in H.P. — Minimum — Normal (2)	Capacity in H.P. — Nine-Monthly Average
3 A.1 ...	Tjidano ...	Koebang (3) ...	5,400	5,400	5,400
3 A.2 ...	Tjidano ...	Pasang (3) ...	2,100	2,100	2,100
10 B.5 ...	Tjianten ...	Leuwiliang ...	1,650	2,300	4,200
16 C.3 ...	Tjisangkoej ...	Tjikalong (4)...	2,190	2,500	2,500
16 F.4 ...	Tjitaroem ...	Kiara... ...	9,500	15,000	50,000
16 F.5 ...	Tjitaroem ...	Goeha ...	1,700	2,700	8,900
16 M.1 ...	Tjiatroem ...	Ploembon ...	3,000	9,600	24,000
50 A.1 ...	Kali Toentang ...	Toentang ...	3,000	3,100	10,200
50 A.2 ...	Kali Toentang...	Tapen ...	2,700	4,200	8,400
57 M.1 ...	Kali Konto ...	Maron ...	7,700	8,400	10,500
57 M.3 ...	Kali Konto ...	Siman ...	4,700	6,000	7,400
90 A.1a ...	Kali Serajoe ...	Garoeng I (5)	3,500	3,500	3,500
90 A.1b ...	Kali Serajoe ...	Garoeng II (5)	4,900	4,900	4,900
99 A.3 ...	Tjilaki	Tjibolang ...	4,700	5,700	9,100
107 B.2 ...	Tjitjatih ...	Bodjong ...	2,400	5,200	7,700
107 B.6 ...	Tjimandiri ...	Halimoen ...	7,150	14,800	22,000
		Total ...	66,290	95,400	180,000

TABLE XXXII (*Continued*)

B. SUMATRA

No.	Name	Capacity in H.P. Normal Minimum (2)	Capacity in H.P. Nine-Monthly Average
53-1-8	Asahan		
	53 1 Halim I	59,200	79,600
	53 2 Si Morea II	83,500	112,000
	53 3 Wilhelminaval III	160,200	215,000
	53 4 Tanggaval IV	147,200	197,000
	53 5 V	38,000	50,800
	53 6 VI	98,800	132,000
	53 7 VII	52,300	69,700
	53 8 VIII	24,200	32,100
	Total	663,400	888,200

C. CELEBES

No.	Name	Capacity in H.P. Normal Minimum (2)	Capacity in H.P. Nine-Monthly Average
57	La Rona-river	144,000	201,000
26 A.1	Posso-river I	110,000	165,000
	Do. II	100,000	150,000
125	Kali Naean	16,600	24,900
128 1	Tondano-river I	5,400	9,600
128 2	Do. II	4,275	7,695
128 3	Do. III	6,850	12,450
128 4	Do. IV	5,145	9,350
	Total	392,270	579,995

only exceptions being Australia, New Zealand, and Tasmania. Japan has already been discussed, while a recent publication of the Water Power Commission of the Dutch East Indies gives the first reliable statistics of the water power resources of those islands. The result of their survey is given in tabular form below. According to it, the total water power resources of the three territories, Java, Sumatra, and Celibes, on a 90 per cent. basis, were 1,126,960 H.P.; on a 75 per cent basis 1,648,995 H.P. Apart from this, additional estimates, covering water power resources not yet closely surveyed, raised the total to 3,448,650 H.P., and the water power plants actually developed or under construction was given as 42,343 H.P. These statistics bear on the year 1927.

No useful information could be served by attempting, on the basis of this additional information, to correct and modify the compilation made by the *U.S. Geological Survey.* The point must be emphasised at the outset that neither the *U.S. Geological Survey* statistics nor any compilation made by ourselves can be regarded as at all final. The countries regarding which exact information is available are limited in number, and it is doubtful whether, even in the most perfectly surveyed territory, a final figure can be realised. Thus even the American and Canadian statistics are subject to modification every year. We can classify as countries where a first approximation has been made towards the assessment of water power resources the following :—U.S.A., Canada, New Zealand, Tasmania, Great Britain, Norway, Switzerland, Austria, Japan, Dutch East Indies, Czecho-Slovakia, and Germany. As far as our investigation goes, the rest of the world remains to be examined right from the beginning. Conjecture and a more or less intelligent guess have been allowed to take the place of scientific observation.

SECTION IV

ELECTRICAL POWER PRODUCTION

SECTION IV

ELECTRICAL POWER PRODUCTION

CAPACITY OF GENERATING PLANT AND POWER DEVELOPED—OUTPUT OF TWENTY-FOUR COUNTRIES—MONTHLY OUTPUT OF SIX COUNTRIES —UNITED STATES — GERMANY — AUSTRIA — BELGIAN NATIONAL SCHEME—FRENCH SURVEY—RUSSIA—CZECHO-SLOVAKIA — SPAIN — BRAZIL—ARGENTINA—INDIA—SOUTH AFRICA — NEW ZEALAND — TASMANIA—AUSTRALIA—ALGERIA—MOROCCO.

Some idea of the state of world electrical power development may be derived from statistics of generating plant installed and of the output of electricity in the principal countries. This has been done in the following table with reference to the latest year for which reliable information is available. In the case of ten countries this has been 1927, in eleven countries, 1926, and in three countries, 1925. In Bulgaria, two water power plants of 11,520 H.P. capacity produced 24,700,000 units out of a national total of 25,635,000 units, and two steam power plants of 10,400 H.P. about 8,000,000 units out of a total of 11,087,000 units.

In the first place, a clear distinction should be drawn between the capacity of generating plant installed and the actual capacity used. This refers especially to water power plant. It would be dangerous, for example, to assume that the capacity of water power resources developed is exactly the same as the capacity of generating plant installed, since the latter must include a certain percentage for reserves and must be able to take care of the resources available at a period of maximum flow. A similar consideration applies to steam power plant, with the one exception, however, that the maximum load developed during the year constitutes the maximum capacity of the plant actually required for power generation purposes, while the remainder represents a reserve. It will generally be found that the output per kilowatt of generating plant, or, rather, the hours of effective utilisation during the year are much

higher in countries possessing a predominance of water power plant than in countries depending very largely on steam. This consideration applies very markedly to countries like Canada, Japan, Italy, Switzerland, Sweden, Norway, and Austria. In certain cases, the high degree of utilisation during the year must be attributed to the existence of special industries which are dependent on continuous operation and consume a large volume of power. Thus, in Canada, newsprint production, in Norway, Sweden, Switzerland, and Austria, electro-chemical and electro-metallurgical works explain why these countries should be in a much more favourable position than Germany, or Great Britain, or the United States. We have, therefore, drawn no conclusions regarding the effective utilisation of either water power or steam power resources.

TABLE XXXIII

ELECTRICAL POWER PRODUCTION OF TWENTY-FOUR COUNTRIES

Country	Year of statistics	Capacity of Generating Plant installed (Kilowatts)			Output of Electricity (Millions of Units)
		Water-Power	Steam-Power	Total	
United States	1927	6,970,000	19,580,000	26,550,000	80,205
Germany	1927	740,000	4,960,000	5,700,000	12,444
Canada	1926	2,700,000	120,000	2,820,000	12,093
France	1926	1,719,000	4,624,000	6,343,000	11,347
Great Britain	1927	21,000	4,096,000	5,117,000	8,750
Italy	1927	2,540,000	600,000	3,140,000	8,100
Japan*	1927	1,960,000	1,240,000	3,200,000	8,000
Norway*	1927	1,579,086	—	1,579,086	8,000
Russia*	1927	250,000	1,440,000	1,690,000	4,112
Sweden*	1927	1,100,000	295,000	1,395,000	4,350
Switzerland*	1927	1,820,000	—	1,820,000	3,350
Belgium*	1926	—	1,390,000	1,390,000	3,160
Austria*	1926	450,000	550,000	1,000,000	2,500
Poland	1926	—	—	1,000,000	1,900
Mexico	1926	340,000	75,800	415,800	1,400
Czecho-Slovakia	1926	114,000	666,000	780,000	1,300
Holland	1927	—	665,380	665,380	1,200
New Zealand	1927	103,288	35,627	138,915	540
Roumania*†	1927	—	—	230,000	500‡
Dutch East Indies ..	1927	61,000	129,000	190,000	500
Denmark*	1926/27	—	229,000	229,000	422
Finland	1926	175,000	—	175,000	360
Tasmania	1925	66,000	—	66,000	350
Bulgaria	1927	—	—	—	38

*All plant—private, public supply and industrial.

†105,000 kW. public supply.
80,000 kW. large industrial concerns.
45,000 kW. other sources.

‡Water power accounted for 57,500,000 units out of the total of 440,000,000 units generated by public supply and large industrial concerns.

The output of the twenty-four countries listed, in 1927, may be given as about 175,000 million units, so that a conservative estimate for the world's production of electrical energy would be about 190,000 million units. Six countries, notably the United States, Great Britain, Germany, Italy, Canada, and Switzerland, now issue monthly statistics of electrical power production, and these

TABLE XXXIV

ELECTRICITY OUTPUT ON A MONTHLY BASIS OF SIX COUNTRIES

A. ELECTRICAL POWER PRODUCTION IN U.S.A.

(Millions of kilowatt hours)

Month	1925	1926	1927	1928
	TOTAL			
January	5,573	6,159	6,730	7,264
February	5,001	5,629	6,080	6,870
March	5,392	6,178	6,717	7,246
April	5,181	5,812	6,416	6,853
May	5,240	5,849	6,582	7,130
June	5,246	5,920	6,475	7,010
July	5,389	5,955	6,446	7,140
August	5,465	6,175	6,632	7,510
September	5,495	6,221	6,607	7,282
October	5,949	6,594	6,928	7,926
November	5,786	6,482	6,876	7,752
December	6,153	6,817	7,211	—
Total	65,870	73,791	79,700	—
Monthly Average	5,489	6,149	6,642	—
	STEAM POWER, ETC.			
January	3,879	4,175	4,376	4,526
February	3,258	3,698	3,885	4,286
March	3,352	3,891	4,130	4,386
April	3,159	3,466	3,850	3,903
May	3,213	3,507	3,911	3,943
June	3,399	3,662	3,943	3,906
July	3,511	3,932	4,021	4,068
August	3,695	4,077	2,247	4,465
September	3,885	4,143	4,406	4,490
October	4,148	4,412	4,453	5,050
November	3,839	4,227	4,367	4,972
December	4,176	4,412	4,482	—
Total	43,514	47,602	48,161	—
Monthly Average	3,626	3,967	4,013	—
	WATER POWER			
January	1,695	1,984	2,354	2,738
February	1,742	1,932	2,196	2,584
March	2,040	2,287	2,587	2,860
April	2,022	2,346	2,566	2,949
May	2,027	2,342	2,671	3,187
June	1,847	2,258	2,532	3,104
July	1,878	2,023	2,435	3,075
August	1,770	2,098	2,386	3,045
September	1,610	2,078	2,201	2,791
October	1,801	2,181	2,385	2,876
November	1,947	2,255	2,509	2,781
December	1,977	2,405	2,729	—
Total	22,356	26,189	29,551	—
Monthly Average	1,863	2,182	2,463	—

TABLE XXXIV

B. ELECTRICAL POWER PRODUCTION IN CANADA

(In thousands of kilowatt hours)

Month	Water	Fuel	Total
1925			
April	783,776	11,613	795,389
May	805,752	10,332	816,084
June	776,413	10,462	786,875
July	784,775	11,196	795,971
August	773,045	11,575	784,620
September	809,507	13,307	822,814
October	902,968	15,914	918,882
November	878,404	21,776	900,180
December	950,228	16,169	996,397
1926			
January	936,034	15,416	951,450
February	856,485	14,045	870,530
March	939,537	12,739	952,276
April	891,041	11,004	902,045
May	949,946	10,993	960,939
June	959,913	11,862	971,775
July	952,711	13,458	966,169
August	969,469	12,705	982,174
September	992,793	15,383	1,008,176
October	1,085,228	15,185	1,100,413
November	1,096,629	15,434	1,112,063
December	1,127,185	18,538	1,145,723
1927			
January	1,113,899	17,313	1,131,212
February	1,050,057	15,793	1,065,850
March	1,133,785	16,223	1,150,008
April	1,094,646	15,075	1,109,721
May	1,101,834	13,768	1,115,602
June	1,094,726	13,201	1,107,927
July	1,089,688	14,572	1,104,260
August	1,213,531	15,558	1,229,089
September	1,181,173	15,850	1,197,023
October	1,289,967	19,203	1,309,170
November	1,289,242	21,969	1,311,211
December	1,339,206	22,658	1,361,864
1928			
January	1.303,908	20,158	1,324,066
February	1,262,241	17,852	1,280,093
March	1,322,790	17,939	1,340,729
April	1,252,530	16,428	1,268,958
May	1,262,226	15,983	1,278,209
June	1,226,458	14,089	1,240,547
July	1,231,147	14,955	1,246,102
August	1,292,129	15,925	1,308,054
September	1,259,519	18,788	1,278,307
October	1,436,456	20,971	1,457,427
November	1,414,317	24,563	1,438,880

are given in Table XXXIV. Those countries between them account for almost 67 per cent. of the output of the twenty-four countries and about 62 per cent. of the world output, so that, even now, we have a fairly clear idea of the state of power development in the world month by month. The inclusion of France, Japan, Norway, Sweden, Russia, and Belgium, and perhaps Austria would

TABLE XXXIV

C. ELECTRICAL POWER PRODUCTION IN SWITZERLAND (1926-1928)

(Thousands of Units)

Month	Water Power (including imported energy)	Steam Power	Total
1926			
October	247,800	100	247,900
November	249,200	100	249,000
December	255,400	300	255,700
1927			
January	243,000	200	243,200
February	226,900	200	227,100
March	250,900	—	250,900
April	252,700	—	252,700
May	264,500	200	264,700
June	259,290	10	259,300
July	270,200	—	270,200
August	276,400	200	276,600
September	278,500	300	278,800
October	283,700	100	283,000
November	272,500	100	272,600
December	281,900	500	282,400
1928			
January	267,700	300	268,000
February	255,200	300	255,500
March	279,900	—	279,900
April	265,800	—	265,800
May	289,300	—	289,300
June	285,400	700	286,100
July	296,880	20	296,900
August	306,760	40	306,800
September	298,390	10	298,400
October	298,170	30	298,200
November	295,760	40	295,800

cover the leading power countries and would allow us to establish, month by month, what might be regarded as a world survey.

Analysing conditions in a number of countries, we find an analysis made by the *U.S. Geological Survey* of the water power situation showed that, out of a total inventory of 69,000,000 H.P. in the United States, 9,600,000 H.P. had been developed (which

compares with a total installed capacity of 12,926,000 H.P.); 6,000,000 H.P. would be developed in the near future; 12,000,000 H.P., capable of exploitation, was being held up by political controversies or restrictive state laws; leaving a balance of 31,400,000 H.P., which could not be profitably developed under present economic conditions.

TABLE XXXIV

D. ELECTRICAL POWER PRODUCTION IN ITALY

(176 Undertakings)

Month	Electricity Output (Units)		
	Water Power	Steam Power	Total
1926			
January	451,863,989	47,049,904	498,913,893
February	429,353,499	25,006,912	454,360,411
March	464,668,218	25,838,836	490,507,054
April	462,981,785	9,117,501	472,099,286
May	501,562,209	10,487,115	512,049,324
June	493,171,289	10,545,693	503,716,982
July	523,658,707	13,862,394	537,521,101
August	507,146,867	17,901,591	525,048,458
September	487,923,783	26,934,801	514,858,584
October	480,859,164	35,708,925	516,568,089
November	504,373,708	15,886,204	520,259,912
December	526,491,645	17,206,077	543,697,722
Total	5,834,054,863	255 545 953	6,089,600,816
1927			
January	510,296,769	17,289,384	527,586,153
February	468,755,312	20,958,874	489,714,186
March	518,148,245	10,040,087	528,188,332
April	499,310,901	8,186,113	507,497,014
May	526,767,440	8,235,778	535,003,218
June	499,804,480	13,260,438	513,065,118
July	514,325,888	21,626,947	535,952,835
August	488 324,865	20,441,896	508,766,761
September	496,646,534	21,504,441	518,150,975
October	522,997,653	18,840,582	541,838,235
November	502,754,419	20,059,620	522,814,039
December	545,901,945	13,457,010	559,358,955
Total	6,094,034,451	193,901,170	6,287,935,621

This distinction is of very considerable importance, since it does show that a compilation giving the total water power resources of any country does not necessarily mean that those resources can be profitably exploited. In the case of the United States, we have seen that 54 per cent. has been given as incapable of profitable development. According to a calculation made by the Water Power

Development Committee of the National Electric Light Association, the continuous plant capacity available in the United States in 1927 of all plants, steam and water power, was equal to 9,156,000 kW., which is not much more than one-third of the total capacity and would correspond to the maximum load developed in the plants during the year, and, in the case of water power, to the

TABLE XXXIV

E. ELECTRICAL POWER PRODUCTION IN ITALY

(223 Undertakings)

Month	Electricity Output (Units)		
	Water Power	Steam Power	Total
1927			
January	596,622,000	21,753,000	618,375,000
February	536,054,000	27,375,000	563,429,000
March	583,308,000	16,537,000	599,845,000
April	569,967,000	10,076,000	580,043,000
May	619,308,000	9,504,000	628,812,000
June	594,053,000	14,497,000	608,550,000
July	594,519,000	23,123,000	617,642,000
August	590,142,000	22,361,000	612,503,000
September	594,985,000	22,580,000	617,565,000
October	628,642,000	20,757,000	649,399,000
November	599,516,000	24,546,000	624,062,000
December	638,660,000	15,967,000	654,627,000
Total for year ...	7,145,776,000	229,076,000	7,374,852,000
1928			
January	625,044,000	12,828,000	637,872,000
February	599,553,000	11,655,000	611,208,000
March	640,681,000	13,411,000	654,092,000
April	621,471,000	7,287,000	628,758,000
May	696,715,000	8,156,000	704,871,000
June	685,943,000	11,244,000	697,187,000
July	712,206,000	14,589,000	726,795,000
August	683,187,000	26,202,000	709,389,000
September	690,427,000	21,364,000	711,991,000
October	727,201,000	18,386,000	745,587,000
November	731,534,000	14,500,000	746,034,000
December	—	—	—
Total 1 Jan.-30 Nov.	7,414,162,000	159,622,000	7,573,784,000

output of the plant actually in operation during the period of minimum flow.

The German statistics bear directly on public supply undertakings responsible for slightly less than two-thirds of the total electrical output of the country, the statistics being prepared and published by the Association of German Power Undertakings. According to

TABLE XXXIV

F. ELECTRICAL POWER PRODUCTION IN GERMANY

(Output of 122 Stations)

Month	Number of Working Days	Electricity Output	
		Total (Millions of Units)	Daily Output (Thousands of Units)
1925			
January	26	899·3	34,587
February	24	800·1	33,338
March	26	856·2	32,931
April	24	778·1	32,421
May	25	793·4	31,735
June	25	771·6	30,865
July	27	835·9	30,961
August	26	858·6	33,024
September	26	882·4	33,937
October	27	922·5	34,167
November	24	914·3	38,096
December	25	977·4	39,098
1926			
January	25	907·9	36,315
February	24	810·5	33,772
March	27	865·6	32,061
April	24	750·9	31,286
May	24	746·5	31,103
June	26	750·3	28,859
July	27	783·6	29,022
August	26	823·9	31,687
September	26	880·2	33,852
October	26	955·4	36,744
November	25	996·3	39,853
December	26	1,096·2	42,162
1927			
January	25	1,048·0	41,918
February	24	944·0	39,335
March	27	1,023·0	37,890
April	24	922·8	38,449
May	25	949·5	37,980
June	25	900·2	35,866
July	26	948·4	36,479
August	27	1,022·4	37,866
September	26	1,079·2	41,506
October	26	1,164·2	44,778
November	26	1,218·9	46,882
December	26	1,307·2	50,275
1928			
January	26	1,238·9	47,649
February	25	1,126·4	45,056
March	27	1,169·9	43,331
April	23	1,048·9	45,604
May	25	1,083·6	43,346
June	26	1,084·0	41,693
July	26	1,123·5	43,213
August	27	1,215·4	45,016
September	25	1,226·6	49,064
October	27	1,357·1	50,264
November	25	1,304·7	52,189

TABLE XXXIV

G. INDEX OF PRODUCTION OF ELECTRICITY IN GREAT BRITAIN

(Monthly Average 1923-24 = 100)

Date.	Britain, excluding London and Wales.	Coal Mining, Iron and Steel, Shipbuilding, Heavy Engineering.	General Engineering and Automobile Construction.	Chemicals.	Marine Transport, Docks, etc.	Textiles, Cotton and Wool.
1925						
January	129	130	139	151	128	119
February	135	140	139	145	132	122
March ...	131	135	137	160	134	122
April ...	113	118	117	135	107	105
May ...	113	121	124	146	110	106
June ...	102	105	110	134	106	91
July ...	102	105	118	136	108	92
August ...	103	109	104	142	109	93
September	116	117	129	146	129	106
October ...	126	125	139	157	135	110
November	145	143	159	180	151	138
December	142	140	151	178	156	134
1926						
January	139	138	162	184	155	135
February	141	153	161	192	150	134
March ...	135	136	155	161	139	131
April ...	119	121	128	153	127	114
May ...	93	88	103	145	99	90
June ...	100	88	119	157	114	105
July ...	91	77	123	147	110	97
August ...	96	84	112	149	110	101
September	105	88	132	163	127	112
October ...	125	110	148	149	148	131
November	136	119	159	167	161	145
December	148	141	157	183	163	148
1927						
January	158	155	167	212	179	151
February	157	156	165	212	169	150
March ...	147	152	153	187	155	140
April ...	144	144	146	208	151	136
May ...	138	139	151	198	150	129
June ...	126	128	136	206	131	114
July ...	123	118	135	184	140	119
August ...	123	124	130	201	142	113
September	138	133	157	228	159	131
October ...	152	146	166	228	175	146
November	166	155	190	236	192	162
December	180	170	200	220	210	172
1928						
January ...	174	164	195	232	199	172
February	170	162	188	249	195	164
March ...	170	165	192	252	195	159
April ...	149	149	164	226	164	132
May ...	140	136	170	223	163	125
June ...	141	138	160	248	158	130
July ...	131	127	149	248	151	124
August ...	130	131	131	227	147	116
September	150	145	164	263	209	138
October ...	161	153	185	245	222	154
November	178	164	215	240	238	169
December	181	171	210	195	238	176

Prepared by the economic and statistical department of the British Electrical and Allied Manufacturers' Association

these statistics, two-thirds of the national output was concentrated in twenty-three stations generating more than 100,000,000 units each.*

In Austria, developments in the Tyrol, Vorarlberg, and the Achensee, partly in connection with the electrification of the Federal Railways and partly in conjunction with the Bavarian super-power zone, have been so rapid that the statistics given for 1926 may be considerably exceeded during 1927 and 1928. There is no doubt that the future of electrical development in that country will depend very largely on the export of electricity to Germany. According to the statistics of the Austrian Water Power Board, large hydro-electric power plants of 500 H.P. and above, to a total capacity of 497,639 H.P. and with a maximum annual output of 2,795 million units, were already in operation or in course of construction, while a calculation made by Dr. G. Ornig showed that large water power resources in Austria, above 500 H.P., were capable of yielding annually 7,435 million units. They are distributed as follows :—

Danube	3,650	million	units
Enns	1,460	,,	,,
Traun	660	,,	,,
Inn	620	,,	,,
Mur	500	,,	,,
Drau	250	,,	,,
Vorarlberger Ill	150	,,	,,
Salzach	145	,,	,,

These figures include plants actually in operation or under construction, so that the total water power resources of the country, measured in units, would be in excess of 10,000 millions.

A further calculation made by the same authority gives the position in Austria as follows :—

	Million Units
Maximum output of plant actually installed or under construction	3,866
Maximum output after harnessing of all large water power resources	13,498
Maximum current consumption at 1,000 units per head ...	6,500
Surplus available for export to Germany and other countries	6,998

To these figures should be added smaller water power resources under 500 H.P. yielding possibly an additional 3,000 million units. According to Dr. Ellbogen, the total water power resources of

* The national output of electricity from all sources was, in 1926, 21,217,614,000 units, water power accounting for 3,317,524,000 units. The total capacity of generating plant was 9,555,084 kilowatts.

Germany, under complete utilisation, would yield 26,000 million units, while the total power requirements of that country would not be less than 60,000 million units. This would leave, therefore, 34,000 million units to be derived either from steam power or from imported water power energy supplied by Austrian power stations. One power company alone, namely, the *Vorarlberger Illwerke A.G.*, is engaged in developing water power plant projects, which are calculated to give ultimately 300,000 kW., with a total annual output of 608 million units. All these points are indications of what may be achieved in both Germany and Austria through co-operation on a super-power basis.

In Belgium, a special commission appointed in 1926 to survey the state of national industrial development, entitled the *Commission Nationale de Production Industrielle,* put forward certain recommendations for the entire electrification of the country, which are now being carried out. The programme put forward by the Commission for the development of electricity supply on a scientific basis envisaged the construction of six super-power steam generating stations—three on the Scheldt, at Antwerp, Ghent, and Antoing; two on the Meuse, at Liege and Namur; and one on the Antwerp-Liege Canal; the construction of five stations using waste heat from blast furnaces, iron and steel plant at Athas, Liege, Charleroi, Mons, and Clabecq; and, finally, the construction of two water power stations at La Roche and Amay.

When the national scheme is complete, the total capacity of generating plant installed will be 1,167,000 kW. of steam plant, 215,000 kW. of gas plant, and 125,000 kW. of water power plant—a grand total of 1,507,000 kW., which is only 240,000 kW. greater than the present figure for the entire country, including industry. The production of electricity would rise to 6,950 million units, 4,648 million units being generated by the six super-power steam stations, 1,887 million units by the waste heat stations, and 415,000,000 units from water power.

In France, the *Commission Nationale Economique* was constituted in 1925 to survey the whole economic position of France, and it carried out a survey of the power situation in the Eastern iron and steel area, making suggestions for future development. In addition to this, authorisation has now been granted by the Government to develop the water power resources of the Rhine from Strasbourg southward. The position in the Eastern area of France, therefore, might be given as follows :—The consumption

of electricity in the area was, in 1924-25, 600,000,000 units, while it might be estimated at 1,400,000,000 units in 1935, equivalent to a generating plant capacity in the latter year of 520,000 kW. Of the total of 1,400,000,000 units, the Saar coal-fired stations would account for 200,000,000 units and water power for 220,000,000 units, so that 1,000,000,000 units would require to be supplied by stations using imported coal. To this total should be added the power produced and consumed by the iron and steel works themselves, where the capacity of plant actually installed amounts to 420,000 kW. The proposal is now that public supply and metallurgical power stations should be interconnected and the fullest use be made of waste heat from the coke ovens and blast furnaces. Adoption of this plan would allow surplus power to be accumulated equivalent to more than 1,000,000,000 units per annum. The region would become self-sufficient under this system. There are indications of developments already in this direction.

A second significant move can be seen in the authorisation granted in 1927 to the *Société des Forces Motrices du Haut Rhin* to build a water power station at Kembs. This means that one of the biggest water power schemes in Europe will be begun within a short time. The exploitation of the Rhine, according to the scheme, should mean the construction of eight generating plants along the river from Kembs to Strasbourg, with a total final capacity of 581,500 kW., Kembs itself accounting for 80,000 kW. The entire project would cover the period 1927-1940, and it would cost 2,918,750,000 francs on a basis of 4.5 times the pre-war price. The output of electricity under maximum utilisation would reach 4,515,000,000 units and, under normal conditions, 1,755,000,000 units, while the total consumption of power in the area by 1925, including Alsace and the iron and steel districts of the east, would be 1,600,000,000 units, or, allowing for electrification of the Alsace-Lorraine railways, 2,000,000,000 units. The power requirements of the east would be covered either from waste heat or from waste power, or from both.

In Sweden, an official return covering the year 1925, gave the installed capacity of water power plant as 825,000 kW. and of steam power plant as 295,000 kW., or a total of 1,120,000 kW., with an output of 3,672,000,000 units. In 1927, according to Ing. Kleman, of the Swedish Electrical Power Association, the capacity of water power plant was 1,100,000 kW., and the national electricity production 4,350,000,000 units.

Similar official returns issued in Holland gave the number of Dutch generating stations as fifty-two, with a plant capacity of 632,000 kW., a maximum load of 362,000 kW., and an energy output of 1,136,000,000 units. A later estimate gave the plant capacity for 1927 as 665,380 kW., with an output of 1,200,000,000 units.

In Switzerland, the Report of the Federal Water Power Department stated that, in 1927, 234 stations with a capacity of 1,820,000 kilowatts produced 3,350,000,000 units. These stations were grouped as follow :—

Plant Capacity per Station	Number of Stations	Total Capacity H.P.
450 H.P.– 20,000 H.P.	200	711,160
20,000 H.P.– 40,000 H.P.	15	390,470
40,000 H.P.–100,000 H.P.	16	973,555
100,000 H.P. and over ...	3	365,000
Total	234	2,440,185

The statistics are less than the totals generally quoted for Switzerland for power production, but one must deduct the capacity of new plant added in the later months of 1927 and plant not used for the generation of electricity.

In Russia, the electrical development of the country is now being carried out according to a plan drawn up by the Gosplan, the Oswok, and the Glawelektro, three commissions, or, rather, three State organisations, devoted to the utilisation of the power resources of that country. According to their calculations, the following power extensions should be carried out :—

Central industrial area	718,000 kW.
North-Western and North-Eastern area ...	350,000 kW.
Northern Caucasus	148,000 kW.
The Urals	142,000 kW.
Volga Region	53,000 kW.
Western area	44,000 kW.
Siberia	66,000 kW.

According to this national scheme, the total capacity of all electric plant would reach by 1930, 3,000,000 kW., the greater part of the development taking place in the four years 1927-30. The actual water power resources of Russia has been given as 43,000,000 kW., but no one has yet made an effort to decide what percentage of

these resources can be economically exploited. The principal water power stations under construction are :—

Kaluga	3,000 kW.
Sysram	1,700 kW.
Twer	6,000 kW.
Alexandrowsk	480,000 kW.
Swer	54,000 kW.
Swerstroi	100,000 kW.

This gives a total of about 650,000 kW. The actual water power plants constructed and in operation were the Volchow (60,000 kW.), Semo-Awtschaly (13,500 kW. installed and 13,500 kW. projected), Eriwan (4,500 kW.), Abasch (1,500 kW.), Bossu (10,000 kW.). The total capacity of water power plant constructed or projected in Russia since the beginning of the Soviet régime is now a little less than 800,000 kW. The output of electricity by public utility stations in Russia during the year 1926-27 was 2,100 million units, and it is estimated that by 1930-31 this figure will have increased to 6,950 million units. The capacity of these stations was given as 733,635 kW. in the same year spread over 658 stations, eighteen stations accounting for 498,635 kW.

In Czecho-Slovakia, the State has entered into power supply on much the same principle as in Germany, where it has been instrumental in creating power companies operating on the model of private industrial concerns with, however, State control. The sale of energy by these undertakings amounted in 1926 to 347 million units, compared with 159 million units in 1925, while important plants are under construction for the development, on a large scale, of the water power resources of the country.

Water power stations recently built are Moldau (3,400 kW.), Stechovice (19,000 kW.), Wran (9,500 kW.), Kinsberk (15,000 kW.), and Schreckenstein (17,000 kW.), all five stations having a total annual output of slightly less than 218,000,000 units. Water power plants under construction or projected total 150,000 kW., with an annual output of 800,000,000 units, while it is calculated that 2,000,000,000 units should be available from water power resources capable of exploitation in the future.

In Spain, no reliable statistics have yet been compiled, although a special State organisation has been created for the purpose. It has been calculated that the water power resources actually available and not yet utilised amount to 4,200,000 kW., with 3,500,000 kW. utilised. E. Gallego (*La Energia Elettrica*, January 10, 1928), gives the figure of 920,000 kW., and the latter figure would appear

to be much more accurate. The output of electricity in Spain has been given as 5,500 million units. The water power resources still to be utilised are distributed as follows :—

Ebro	2,300,000 kW.
Douro	600,000 kW.
Jucar	410,000 kW.
Guadalquivir	320,000 kW.
Tagus	260,000 kW.
Mina	110,000 kW.
Guadiana	44,000 kW.
Other Rivers	390,000 kW.

Power projects which have been under construction cover the Douro, where 370,000 kW. should be developed, 220,000 kW. being destined for Spain and 150,000 kW. for Portugal, while the total capacity of plant would amount to 600,000 kW. under full development. A special company, with a capital of 150,000,000 pesetas, has been founded for this purpose. Similarly, another company has come into existence to exploit the Jucar, with a total development programme of 220,000 kW., while a group of three companies has harnessed 75,000 kW. of the power resources of the Guadalquivir. A fourth undertaking, founded in 1926, aims at developing six stations in the Alberche, with an ultimate capacity of 150,000 kW.

These notes merely form an indication of what is being carried out in a number of the more important European countries.

Outside of Europe, Japan, and North America, little real information is available regarding the state of electrical development in the world. In South America, an investigation is now being carried out into the water power resources of Brazil by Brazilian Government Departments, and measurements of 154 important waterfalls out of a total of 378 available showed that 50,000,000 H.P. might be developed, with a possible remaining 10,000,000 H.P., yielding, therefore, for the entire country, 45,000,000 kW. Smaller waterfalls, with a potential capacity ranging between 50,000 and 60,000 H.P. have not been surveyed, but it is estimated that, in the State of Parana alone, 1,550,000 H.P. should be available from this source alone.

The principal countries operating in the state are the *Rio de Janeiro Tramways, Light, and Power Co.*, with hydraulic plant, developed 50,000 H.P., destined to be extended ultimately to 200,000 H.P.; the *San Paulo Tramways, Light, and Power Co.*, with 200,000 H.P. developed on the Sena, with an additional 250,000 H.P. projected. A third company, with an annual output in excess of 600 million units—namely, the *Brazilian Light, Power,*

and Traction Co., is perhaps the most important operating in South America. Other companies operate in the vicinity of Rio de Janeiro and in the State of Minas Geræs, but the most important developments have been carried out by the three companies already mentioned.

In the Argentine, progress has been concentrated on Buenos Aires, where two power companies, with a total output of a little less than 800,000,000 units, have been responsible for the greater part of the developments. No attempt has yet been made in that country to survey water power developments, but there have been investigations bearing on the more readily accessible power possibilities of the two rivers, the Apipe and the Iguazu, and on the further power potentialities of the Salto Grande. According to these investigations, the total power capable of being developed is as follows :—

Apipe	415,000 kW.
Iguazu	250,000 kW.
Salto Grande	200,000 kW.

yielding a grand total of 865,000 kW. The hydro-electric potentialities of the Argentine are much greater than these statistics would indicate, but no reliable investigation has yet been carried out in the State as a whole.

In the British Empire, fairly complete statistics of power resources for Australia, New Zealand, and Tasmania, were presented to the World Power Conference in 1924, and since then developments have been carried out on the lines indicated. The two Dominions regarding which little real information is available are India and South Africa. In India, a comprehensive survey has been carried out into the water power resources of the Punjab, which showed that there is no less than 1,770,000 kW. capable of commercial development in the Punjab rivers, the Beas river alone accounting for 830,000 kW. Of this total, 8,200 kW. have been developed, while a further 36,000 kW. are under construction. The first principal development projected by the Punjab company bears on the utilisation of the Uhl river, a tributary of the Beas. A first power station, capable of generating 36,000 kW. would be designed, followed by a second station lower down of 48,000 kW., while increased storage capacity would supply an additional 34,000 kW. to the first project, yielding a grand total of 118,600 kW. This project was initiated in 1926 and is now under construction.

In South Africa, according to statistics prepared by the Government, the total output of electricity in 1925 was given as 1,512 million units, the mines accounting for 78 per cent. of the total consumed. Such an output would correspond to about 700,000 kW. of generating plant installed. The principal undertakings are the Victoria Falls and Transvaal Power Company, the Electricity Supply Commission and the South African Rys. The Victoria Falls and Transvaal Power Co. sold during 1927 1,128 million units, and is probably responsible for about 50 per cent. of the entire output of the Union.

In New Zealand, the total capacity of all the plant installed in 1927 was 138,915 kW., 103,288 kW. of which were hydro-electric. The State-controlled undertakings at Lake Coleridge (27,000 kW.), Mangahao (20,000 kW.), Hora-Hora (10,300 kW.), with a total plant capacity of 57,300 kW., generated in 1927 237,128,000 units. Applying this ratio to the entire country, we should give the total output of New Zealand as a whole as about 540 million units. The principal undertakings in New Zealand, apart from the State, are the Auckland Power Board, with an output in 1927 of 83,427,000 units; the Southland Power Board, with 21,124,000 units in the same period; Dunedin Municipality, with 31,744,000 units sold during the year ending March, 1927; New Plymouth Municipality, with an output during 1927 of 10,663,000 units; Wellington Corporation, with 6,506,000 units in the same period; and the Wanganui undertaking, with 4,179,000 units. These six undertakings, in addition to the State, were responsible for an output of slightly over 400 million units in 1927. The most important developments, either under construction or projected, are the Waikairemoana plant, with 40,000 kW., to be in operation by June, 1929, with an ultimate extension to 100,000 kW.; the new station at Kurow, with 30,000 kW. initially installed and an ultimate extension to 75,000 kW.; Lake Coleridge, with an additional 7,500 kW.; and Dunedin, with a future extension from its existing 11,000 kW. to 28,000 kW.

In Tasmania, where practically the whole output of the island is centred in the Waddamana power station, a total output in 1927 of 290 million units was recorded, with connections to the system of 64,114 kW. The only plant of any importance outside of Waddamana is that owned by the Launceston Municipality, which generated in 1927 2,606,000 units.

In Australia, the position may be described with reference to the most important undertakings. In Victoria, the State Electricity Commission is the most important single undertaking, although it does not meet all the requirements of the State. It has installed at present a total capacity of 87,500 kW., composed of 60,000 kW. at Yallourn, 16,000 kW. at the Newport B. power station, and 11,500 kW. at the Rubicon hydro-electric power plant. At the beginning of 1929 a new generating unit of 15,000 kW. will be brought into operation at the Richmond power station, which will bring the total capacity up to 102,500 kW. The output of electricity by this Commission is now about 350,000,000 units. The extensions proposed by this commission include 25,000 kW. sets for the Yallourn station.

In New South Wales, the most important developments have been concentrated in the capital at Sydney and in the Railways Department. Sydney Corporation, with a total plant capacity of 75,000 kW., generated in 1927 219,773,000 units and purchased 115,863,000 units from the Railways Department. It has placed orders for 150,000 kW. to be installed in a new station at Bunnerong, which will be extended ultimately to 300,000 kW., while the Railways Department has decided to extend its Utilmo station from its present 27,500 kW. to 107,500 kW., 40,000 kW. having been ordered. A new station with an initial capacity of 5,000 kW. has been built at Lithgow. Outside of Sydney, the Newcastle Municipality, with 26,500 kW. installed, has ordered an additional 7,500 kW., while the Barrenjack water power project with 10,000 kW. is now in operation.

In South Australia, the principal developments have taken place in the system owned by the Adelaide Electric Supply Co., which has an output of over 88,000,000 units. Its present plant capacity of 30,000 kW. will be extended by an additional 25,000 kW. now on order. In Western Australia, the capital at Perth, with a power consumption of 30,000,000 units per annum, is first in importance. We can assess the total output of electricity in Australia at more than 1,800 million units annually.

At a number of isolated points, surveys have been carried out during recent years. In Algeria, one company, the *Société Algerienne de Force et Lumière,* with an output of about 150,000,000 units, has been responsible for practically all the developments which have taken place in that country. In Morocco, the average annual capacity of water power resources has been given as about

88,000 kW., while the output of electricity in 1927 for the whole territory was 33,000,000 units. The first movement towards the electrification of Morocco on a scientific basis included the construction of a main transmission system operating at 50,000 volts extending over 650 kilometres. At the present time, 230 kilometres have been constructed from Casablanca to Rabat and Kourigha, with a further extension from Rabat to Kénitra of over 40 kilometres. A steam power station of 18,000 kW. has been built at Casablanca to feed into this system, while a water power station at Sidi-Macheu will enter into operation in 1929. A further development, which will be based on the utilisation of water power resources of the Middle Atlas, is under construction.

SECTION V

WORLD POWER PRODUCTION

SECTION V

WORLD POWER PRODUCTION

WORLD PRODUCTION ON A COMMON BASIS IN 1927—SIGNIFICANCE OF VARIOUS FORMS OF POWER.

In the light of the information given in the previous sections of this monograph, it may be possible to obtain some idea of the world's power resources or world power production on a common basis. Such a common basis may be either calories, or its British equivalent, B.Th.U.'s, or kilowatt hours—assuming in the latter case that the entire power-producing materials are used for the generation of electricity. Or it might be found advisable to use coal as the general basis, assuming that the calorific value of this fuel is fairly standard for all bituminous coals and anthracites taken as a whole. On all three bases, estimates have been made.

TABLE XXXV

WORLD POWER PRODUCTION

In 1913, 1920, 1923 and 1925

(Billions of B.Th.U.'s)

Source of Power	1913	1920	1923	1925
Hard Coal	34,986	33,739	34,797	34,400
Brown Coal	1,250	1,470	1,520	1,730
Total Coal	36,236	35,209	36,317	36,130
Oil and Gas	2,938	5,030	7,081	7,700
Water Power	1,750	2,660	3,580	4,000
Grand Total	40,924	42,899	46,978	47,830
	Proportion represented by different classes			
Hard Coal	85·5	78·7	74·1	71·9
Brown Coal	3·0	3·4	3·2	3·6
Total Coal	88·5	82·1	77·3	75·5
Oil and Gas	7·2	11·7	15·1	16·1
Water Power	4·3	6·2	7·6	8·4
Grand Total	100·0	100·0	100·0	100·0

Thus, according to F. G. Tryon, of the American Bureau of Mines, the world's power consumption, measured in B.Th.U.'s, was as in Table XXXV during the four years, 1913, 1920, 1923, 1925.

According to this table, hard coal is becoming much less important as a power-generating material. In 1913, it accounted for 85.5 per cent. of the world's power production, but, in 1925, it had fallen to 71.9 per cent. Including brown coal, it accounted in the latter year for 75.5 per cent. Brown coal, as the figures show, has not made any great impression on the situation, the most revolutionary developments having taken place in oil and gas, first of all, and in water power. These subsidiary sources between them accounted for an additional 13 per cent. These substitutes for coal would account for not less than 230,000,000 tons, water power being responsible for roughly 80,000,000 tons. Coal, according to these calculations, is steadily yielding ground to both oil and water power as a source of power. According to a compilation made by the Dresdner Bank in its publication, *The Economic Forces of the World,* which has been based largely on documents submitted to the International Economic Conference, the total output of energy-producing materials in 1925 was given as 1,589,000,000 tons. Oil accounted for 233,780,000 tons, and water power for 120,700,000 tons, or a total between them of 354,400,000 tons, while the corresponding figure in 1913 would be about 160,000,000 tons. These estimates correspond fairly closely with the calculations made by F. G. Tryon, probably owing to the fact that the source of information used in both cases was the *U.S. Geological Survey.*

In the same publication, the Dresdner Bank made an estimate of the world's power resources converted into coal. According to it, coal alone accounted for 5,629,016 million tons, oil resources for 9,934 millions, and water power resources for 1,991 millions, or a grand total of 5,640,941 million tons. If we were to adopt this estimate, the world's power resources at the present rate of consumption would last over 3,500 years.

Sir Philip Nash, in his paper on "The Economics of World Power," delivered to the 1924 World Power Conference, reduced the coal, oil and water power production of the world to an electrical basis. He assumed that all the water power resources of the world could be harnessed and that the annual production of coal and oil could be brought into line with it. On this basis he estimated the world's output for 1913 at 2,666,000 million units and, for 1921, at 2,192,000 million units. For six countries—namely, Great

TABLE XXXVI

COMPARISON BETWEEN THE WORLD'S THREE PRINCIPAL SOURCES OF ENERGY: COAL, OIL, AND WATER POWER (1925)

Country	Present Annual Production (million tons and % of world totals)								Available Resources (million tons and % of world totals)					
	Coal and Lignite output in 1925 (the latter converted into coal)		1925 output of oil converted into coal		Utilised water power converted into coal saved annually		Total 1925 output of energy producing materials† converted into coal		Coal and Lignite resources (the latter converted into coal)		Oil resources converted into coal		Annual capacity of existing water power converted into coal	
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
German Reich	163·7	13·3	—*	—	4·4	3·7	168·1	10·6	240,715	4·3	—*	—	8·0	0·4
Great Britain	247·1	20·0	—	—	1·0	0·9	248·1	15·6	189,533	3·4	—	—	3·4	0·1
France	47·3	3·8	—*	—	8·4	6·9	55·7	3·5	32,406	0·6	—*	—	32·0	1·6
Russia (European)	14·1	1·1	11·8	5·0	0·4	0·3	26·3	1·7	57,115	1·0	1571·4	15·8	8·0	0·4
Rest of Europe	113·0	9·2	5·2	2·2	33·6	27·8	151·8	9·5	255,408	4·5	262·4	2·6	181·2	9·2
EUROPE	585·2	47·4	17·0	7·2	47·8	39·6	650·0	40·9	775,177	13·8	1,833·8	18·4	232·6	11·7
United States	530·8	43·0	164·4	70·3	40·0	33·1	735·2	46·3	2,735,527	48·6	1,618·6	16·3	140·0	7·0
Canada	9·3	0·7	—	—	12·8	10·6	22·1	1·4	667,095	11·9	223·1	2·3	104·0	5·2
Mexico	—	—	27·0	11·5	2·0	1·7	29·0	1·8	—	—	1,045·0	10·5	24·0	1·2
Rest of America	2·2	0·2	9·6	4·2	2·9	2·4	14·7	0·9	32,580	0·5	2,175·0	21·9	212·4	10·7
AMERICA	542·3	43·9	201·0	86·0	57·7	47·8	801·0	50·4	3,435,202	61·0	5,061·7	51·0	480·4	24·1
China	20·0	1·6	—	—	—	—	20·0	1·3	995,228	17·7	308·6	3·1	80·0	4·0
Japan	29·2	2·4	—	—	12·0	10·0	41·2	2·6	7,570	0·1	277·2	2·8	56·0	2·9
British India	20·2	1·6	2·8	1·2	1·6	1·3	24·6	1·5	77,445	1·4	927·1	9·3	29·6	1·5
Dutch Indies	—	—	4·7	2·0	0·3	0·2	5·0	0·3	—	—	927·1	9·3	60·0	3·0
Siberia	2·3	0·2	—	—	0·4	0·3	2·7	0·2	109,388	2·0	—	—	204·0	10·2
Rest of Asia	—	—	7·9	3·4	—	—	7·9	0·5	23,068	0·4	1,312·4	13·2	62·8	3·1
ASIA	71·7	5·8	15·4	6·6	14·3	11·8	101·4	6·4	1,212,699	21·6	2,825·3	28·4	492·4	24·7
AUSTRALIA	18·7	1·5	—	—	0·8	0·7	19·5	1·2	148,709	2·6	—	—	26·0	1·3
AFRICA	17·1	1·4	0·3	0·2	0·1	0·1	17·5	1·1	57,229	1·0	213·7	2·2	760·0	38·2
WORLD TOTALS	1,235·0	100·0	233·7	100·0	120·7	100·0	1,589·4	100·0	5,629,016	100·0	9,934·5	100·0	1,991·4	100·0

†In order to compare coal, oil and water power, one has to convert the energy recovered, or recoverable, from water power into the quantity of coal saved by it. For this purpose we start in the above table from the assumption that water power can be utilised for an average of 6,000 hours annually. At the same time it is being assumed that in analogy with the rate of utilisation found in modern large thermitic power works, an electric unit is equal to 1 kg. of coal.; *e.g.*, Germany's water power already utilised amounts, according to our table, to 1·1 million H.P. Taking a working year=6,000 hours, and an electric unit=1·5 H.P., an efficiency will result

$$=\frac{1{\cdot}1\ .\ 6000}{1{\cdot}5}=4{,}400 \text{ million units}=\text{consumption of } 4{\cdot}4 \text{ million tons of coal.}$$

*Very small.

Britain, U.S.A., France, Germany, Italy, and Switzerland—he gave the total energy available in 1920 from all sources as 909 thousand million units, while the actual power consumption was 76 thousand million units, giving an electric utilisation factor of 8.36 per cent. He based his calculations on the assumption that 3.11 lb. of coal would be required to generate one electrical unit, while, with oil, 2.08 lb. for fuel oil with a 60.8 per cent. burning content has been taken as the basis per unit of electricity generated. For water power an annual output per kilowatt of 2,500 units was taken. All these methods of calculation, owing to rapid technical progress in electrical power production, have since been proved to be too conservative, and new standards must, therefore, be substituted.

We have made an effort in the following table to give the world power production in 1927 on the three bases—coal, calories, and

TABLE XXXVII
POWER PRODUCTION OF THE WORLD
(1927)

Basis	Category	Europe	America	Asia	Oceania	Africa	World
Coal (Millions of Tons)	Hard Coal	615·5	557·2	74·4	17·2	12·1	1,276·4
	Brown Coal	33·6	1·0	—	—	—	—
	Oil	24·8	222·0	14·6	—	—	260·0
	Water Power	35·0	42·0	6·5	·9	·4	84·8
	Total	708·9	822·2	95·5	18·1	12·5	1,655·8
Calories (Thousands of Millions)	Hard Coal	3,693	3,343	446	103	73	7,658
	Brown Coal	201	6	—	—	—	207
	Oil	168	1,332	87	—	—	1,587
	Water Power	210	252	39	5	2	508
	Total	4,272	4,933	572	108	75	9,960
kWh. (Millions of Units)	Hard Coal	615,500	557,200	74,400	17,200	12,100	1,276,400
	Brown Coal	33,600	1,000	—	—	—	34,600
	Oil	24,800	222,000	14,600	—	—	260,000
	Water Power	35,000	42,000	6,500	900	400	84,800
	Total	708,900	822,200	95,500	18,100	12,500	1,655,800

electrical units. For coal, the calorific value per kilogram has been taken as 6,000 calories. We have assumed that 4.5 tons of brown coal are equivalent to one ton of hard coal, and that oil has, weight for weight, a 57 per cent. greater calorific value than hard coal. We have also assumed that the average number of calories required to produce one unit of electricity has been exactly 6,000 and, instead of adopting a purely arbitrary total per H.P. of water power actually utilised, we have made an effort to get the production in units of the water power plant operating in the principal industrial countries. These units have been converted to coal on the basis of 6,000 calories per unit. Where information was available, we have made allowance for the output of electricity by water

power plant in private and industrial concerns. This method, in our opinion, has a stronger statistical basis than theoretical calculations.

In view of the state of our knowledge regarding the world's power resources, it would be inadvisable for us to attempt any additional correlation between production and resources with a view to determining how long the latter will last. While this last statistical compilation prepared by ourselves shows an increase in the world's power production on a coal basis since 1925, it does not coincide with the estimate made by the U.S. Bureau of Mines or by the Dresdner Bank, the discrepancy being due to the different conception we have had of water power development. Instead of adopting a theoretical tonnage of coal equivalent to one H.P. of hydro-electrical development per annum, we have taken the output, as measured in units, of the countries regarding which we have satisfactory knowledge, made an estimate for various additional countries within the continents mentioned and, on this total, calculated the coal consumption represented by water power. The result of this has been that water power in 1927 accounted for 85 million tons, or 35 million tons less than the figure given by the Dresdner Bank for 1925. We believe that this estimate comes closer to reality than any of the estimates already quoted.

We have already given the world output of electrical energy in 1927 as 190,000 million units, while the potential world output, including natural gas and other subsidiary sources of fuel, would have been in excess of 1,700,000 million units (assuming, of course, that all power-producing materials were used for the generation of electricity). On this calculation, electrical power production represented slightly more than 11 per cent. of the total power production of the world in that year. This compares with the estimate of 8.34 per cent. made by Sir Philip Nash in 1924, based on statistics for six countries. If we apply to the statistics compiled by Sir Philip Nash the method of assessing water power production adopted here, we should find that electricity accounted in that year for probably 9 per cent. of the world's power output.

The two continents capable of greatest development are America and Asia. Practically all the South American States are virgin, while, in Asia, China, India, and Siberia, remain to be exploited. Africa and Oceania, although they have practically an insignificant power output at the present time, may develop much more rapidly than the rest of the world, but, in their case, the resources are not

actually available, or at least, a survey of their resources has not been sufficiently complete or sufficiently detailed to allow of anything but the preparation of statistics which may prove to be absurdly conservative. Europe is exploiting much more thoroughly than the rest of the world its power resources, not only in coal but also in oil and water power. In the last-named, the state of power development in Europe is almost exactly equivalent to that in America, contrary to what has been generally assumed. Outside of these two continents, few developments of importance have taken place, and there is evidently room for concentration of enterprise in the three continents other than Europe and America.

CONCLUSIONS

CONCLUSIONS

The main conclusions which have been inspired by this investigation may now be summarised. It has been impossible to go into very close detail, owing to the fact that we have been concerned primarily with the broader aspects of the subject. We assume that the work to be carried out now by the World Power Conference will cover adequately all further detailed investigation.

With reference to coal, even the most cursory examination is sufficient to show that the statistics of the world resources, prepared for and submitted to the Toronto Geological Congress, require considerable amendation. It is doubtful whether the estimates given for any one country would now stand the test of investigation. The growth of geological research and improvement in the methods of determining the presence and volume of mineral resources have been such as to render necessary, in our opinion, an entirely new world survey.

We would suggest, in this connection, that the distinction between the three categories generally adopted in assessing the world's coal resources—namely, ascertained or actually surveyed, possible, and potential—should be abolished, and that estimates should be based entirely on the coal reserves which have been actually surveyed and can be econmically exploited. In the second place, a limiting factor should be introduced into the consideration of the depths to which the coal resources extend. It is generally agreed that 4,000 feet represents the limit to which coal-mining operations can be carried out on an economic basis. The growth of technical improvements may render it possible to extend that depth, but, for the purposes of a first world survey of coal resources, a limit should be imposed of 1,000 metres. It is essential that comparatively accurate information should be obtained which is not subject to widely conflicting theories and calculations, and it is with this end in view that we have made the above recommendations.

Again, there should be a very clear distinction drawn between the main classes of coals. This distinction should be based either

on the calorific value or on the commercial value of the various classes. Thus, it is not sufficient to divide the world's resources into three classes—anthracite, bituminous, and all others. Among the last-named we find lignites, brown coal, culms, and other types which cannot be regarded at present as of sufficient value to justify exploitation.

We suggest, therefore, that the distinction between anthracite and bituminous coals should be maintained, but that a more exact definition should be given of the former. The classification adopted for a number of countries is not such as to make the division between these two groups satisfactory. One possible alternative lies, of course, in the abolition of the distinction entirely, anthracites and bituminous coals being grouped together within definite calorific limits. There should also be a very clear distinction between what is termed brown coal and lignites. It is possible to group into one and the same category the brown coals which have been exploited in Germany and in Australia with the lignites of Italy or Czecho-Slovakia, and a clear distinction should be drawn, based either on calorific value or on moisture content or on both. The five main divisions suggested, therefore, are :—anthracites, bituminous coals, brown coal, lignites, and all others.

With reference to statistics of production, we are convinced that it is impossible to separate the question of resources from production, even if the terms of reference on which this investigation has been carried out make no mention of the latter. In the coal industry especially, world statistics of a comparatively reliable nature have always been available, and are issued monthly in the case of a number of countries and annually for practically every coal-producing country in the world. By means of these production statistics it is possible to obtain a view of the entire position and the main tendencies in coal consumption, all of which afford some indication of the rate at which the coal resources of any one country are being exhausted.

A further consideration of some value lies in statistics of coke production. The statistics in this connection are not satisfactory and are not sufficiently accurate to afford any real indication of the world production and consumption of that material, either for metallurgical or for gasworks purposes. The significance of coke-production lies in the waste gases and waste heat, which are a by-product of the distillation processes, and they should be added to the world's gas resources, taken on a purely annual basis.

A second power resource of interest is oil, either alone or combined with natural gas. There are certain difficulties attending any survey of the world's oil or natural gas resources, chief among them being political and financial. In the present state of oil production, where a few international combines dominate the market, it would be dangerous for a number of countries to disclose their oil resources if they had any real knowledge of them, while experts attached to these great combines are surveying the entire world for oil possibilities. We can be sure, therefore, that any statistics that are published of oil resources are probably totally inaccurate and have their real basis in propaganda. We recommend that, for the moment at least, a survey of the oil and natural gas resources of the world should not be undertaken by the World Power Conference.

This observation does not apply to a survey of the oil resources of the world as represented by oil-shales or by oil-bearing geological formations which do not enter into the category of oil wells. Practically nothing has been done in this connection in any country, owing probably to the fact that the utilisation of oil shales has been rendered difficult through the competition of oil from wells and through the steady fall in price of oil products. It might be advisable, however, for this work to be undertaken by the World Power Conference, if only to show how, in the event of oil wells becoming exhausted, alternative supplies would be available.

Water power presents the most difficult problem of all. After examining innumerable statistics pretending to give the water power resources of the world and of individual countries, we have come to the conclusion that it would be better if the entire subject were opened afresh without any reference to existing statistics. An attempt should be made to even out the most glaring discrepancies in the methods of calculation and in the determination of power units to be adopted. When this has been done, it may be possible to examine existing statistics, select those that appear to be accurate and authentic, and concentrate attention on the remaining countries. We can only indicate here certain of the most obvious discrepancies that have been brought to our attention.

In the first place, there are apparently three varieties of horse-power:—

1. Theoretical or water horse-power, which makes no allowance for the efficiency of the water power plant itself;

2. Turbine horse-power, which deals with the capacity of the water turbines themselves, without reference to the generators;
3. Electric horse-power, which includes the generators.

It is obvious that one of these three units must be adopted, and we suggest that turbine horse-power comes perhaps closer to the ideal than either of the other two.

In the second place, the estimates of the power available throughout the year differ very widely, and, in this case, we can distinguish roughly six classes :—

1. Power developed at time of minimum flow, which would represent the period of greatest drought, and, taken as a whole, should be regarded as power available on a 100 per cent. basis.
2. Power available on a 90 per cent. basis, which would represent resources yielding power during the entire year with the exception of the month of greatest drought.
3. Power available during nine months of the year.
4. Power available during six months of the year.
5. The average power available throughout the year. This represents the amount obtained by adding up the totals for twelve months and dividing by twelve.
6. Power available at the period of maximum flow, which may, in some cases, represent one month, and, in other cases, as much as three months.

A further difficulty which occurs in co-ordinating statistics of power actually developed lies in the elasticity of the distinction between minimum power available during the year, the maximum power developed throughout the year on a short period basis (equivalent to the maximum load in a steam-generating station), and the capacity of the plant installed, with due provision being made for reserves. In certain cases, we are furnished with statistics of the plant installed, including reserves; in other cases, with statistics of the maximum load on the plant installed; and, in other cases again, with statistics of the power developed by the plant on a 100 per cent. basis throughout the year, which may be regarded as a base or minimum load.

In our opinion, a clear distinction should be drawn between all these forms and a standard schedule drawn up to avoid differences in classification which may serve to render a world compilation utterly impossible.

A further element of importance lies in the determination of water power storage resources. This refers to reservoir capacity and the possibility of grouping water sheds into one system which can act as reserve during periods of minimum flow. Again, the growth of interconnection and the super-power zone has rendered it advisable to segregate region from region in determining the national water power resources. Thus we may have a period of maximum flow in one region occurring at a totally different time from another, while interconnection between the two regions would allow for elimination of reserve plant and a better overall load. This is a factor which affects primarily the efficient utilisation of water power resources rather than the volume of the resources themselves.

To complete the survey, we attempted to co-ordinate statistics of electric power production, both from water power and steam power plants as well as the capacity of the generating plant installed. In this case again, it would have been inadvisable to isolate the question of the study of water power resources from examination of the present state of exploitation. The rate at which water power resources are developed depends on the capacity of water power plant to compete in capital cost and in unit cost with steam power plant. This consideration applies especially to countries which are in possession of both water power and fuel resources. It is for this reason that steam power plant should be brought into the survey.

Again, an effort should be made to issue monthly statistics of electrical output from the main power countries and, if possible, annual statistics for the principal countries of the world. Such monthly statistics are now being published by Great Britain, Germany, the United States, Canada, Switzerland, and Italy, but we feel that they should be extended to include such countries as Norway, Sweden, Spain, and France.

We are of opinion that other sources of power of an organic nature, such as timber, vegetable products, and peat, should not for the present be surveyed by the World Power Conference.

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NOTE

The compilation of a complete bibliography of the world's power resources would fill many volumes of print, the greater part of it quite useless, owing to the fact that there is perpetual modification and correction of the estimates and calculations. We have decided, therefore, to begin with the year 1924, when the first World Power Conference took place, and bring the compilation up to June, 1928. The information published during those four years has been in itself practically sufficient to permit of the preparation of a survey of the world's power resources, and it is only necessary in certain cases to deal with previous publications.

The main sections covered are:—General, which deals with all power resources or questions relating to the utilisation of power; Coal, Brown Coal, and Lignite; Oil and Liquid Fuels; Water Power; Gas; and Electricity. Each section is arranged according to territorial divisions, which are in the sequence:—World; British Empire; Europe; Balkans; Near East and Russia; North and South America; and the Far East. In each territorial division an alphabetical arrangement is made according to authors or according to principal sources. An asterisk placed before an entry means that, in this case, a bibliography is given of the subject under discussion. By combining the bibliographical references given directly with those published in the various documents enumerated, it should be possible to carry out an almost complete bibliographical survey of the power resources of the world.

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